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| (54) Title: NOVEL MITOGENIC REGULATORS | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <caption>Sequence Identity Data (Estimated from Chart)</caption> <thead> <tr> <th>Sequence</th> <th>Identity (%)</th> </tr> </thead> <tbody> <tr> <td>gp91phox.human</td> <td>65.8</td> </tr> <tr> <td>gp91phox.mouse</td> <td>~32</td> </tr> <tr> <td>gp91phox.bovine</td> <td>~30</td> </tr> <tr> <td>mox2.human</td> <td>~12</td> </tr> <tr> <td>Mox1.human</td> <td>~10</td> </tr> <tr> <td>Mox1.rat</td> <td>~10</td> </tr> <tr> <td>cytb558/arabidopsis.pep</td> <td>~10</td> </tr> <tr> <td>cytb558.rhoe.pep</td> <td>~10</td> </tr> </tbody> </table> | | | Sequence | Identity (%) | gp91phox.human | 65.8 | gp91phox.mouse | ~32 | gp91phox.bovine | ~30 | mox2.human | ~12 | Mox1.human | ~10 | Mox1.rat | ~10 | cytb558/arabidopsis.pep | ~10 | cytb558.rhoe.pep | ~10 |
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| (57) Abstract <p>The present invention relates to new genes encoding for the production of novel proteins involved in generation of reactive oxygen intermediates that affect cell division. The present invention also provides vectors containing these genes, cells transfected with these vectors, antibodies raised against these novel proteins, kits for detection, localization and measurement of these genes and proteins, and methods to determine the activity of drugs to affect the activity of the proteins of the present invention.</p> | | | | | | | | | | | | | | | | | | | | |

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NOVEL MITOGENIC REGULATORS

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TECHNICAL FIELD

The present invention relates to the field of normal and abnormal cell growth, in particular mitogenic regulation. The present invention provides the following: nucleotide sequences encoding for the production of enzymes that are mitogenic regulators; amino acid sequences of these enzymes; vectors containing these nucleotide sequences; methods for transfecting cells with vectors that produce these enzymes; transfected cells; methods for administering these transfected cells to animals to induce tumor formation; and antibodies to these enzymes that are useful for detecting and measuring levels of these enzymes, and for binding to cells possessing extracellular epitopes of these enzymes.

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BACKGROUND OF THE INVENTION

Reactive oxygen intermediates (ROI) are partial reduction products of oxygen: 1 electron reduces O_2 to form superoxide (O_2^-), and 2 electrons reduce O_2 to form hydrogen peroxide (H_2O_2). ROI are generated as a byproduct of aerobic metabolism and by toxicological mechanisms. There is growing evidence for regulated enzymatic generation of O_2^- and its conversion to H_2O_2 in a variety of cells. The conversion of O_2^- to H_2O_2 occurs spontaneously, but is markedly accelerated by superoxide dismutase (SOD). High levels of ROI are associated with damage to biomolecules such as DNA, biomembranes and proteins. Recent evidence indicates generation of ROI under

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normal cellular conditions and points to signaling roles for O_2^- and H_2O_2 .

Several biological systems generate reactive oxygen. Phagocytic cells such as neutrophils generate large quantities of ROI as part of their battery of bactericidal mechanisms. Exposure of neutrophils to bacteria or to various soluble mediators such as formyl-Met-Leu-Phe or phorbol esters activates a massive consumption of oxygen, termed the respiratory burst, to initially generate superoxide, with secondary generation of H_2O_2 , HOCl and hydroxyl radical. The enzyme responsible for this oxygen consumption is the respiratory burst oxidase (nicotinamide adenine dinucleotide phosphate-reduced form (NADPH) oxidase).

There is growing evidence for the generation of ROI by non-phagocytic cells, particularly in situations related to cell proliferation. Significant generation of H_2O_2 , O_2^- , or both have been noted in some cell types. Fibroblasts and human endothelial cells show increased release of superoxide in response to cytokines such as interleukin-1 or tumor necrosis factor (TNF) (Meier et al. (1989) *Biochem J.* 263, 539-545.; Matsubara et al. (1986) *J. Immun.* 137, 3295-3298). Ras-transformed fibroblasts show increased superoxide release compared with control fibroblasts (Irani, et al. (1997) *Science* 275, 1649-1652). Rat vascular smooth muscle cells show increased H_2O_2 release in response to PDGF (Sundaresan et al. (1995) *Science* 270, 296-299) and angiotensin II (Griendling et al. (1994) *Circ. Res.* 74, 1141-1148; Fukui et al. (1997) *Circ. Res.* 80, 45-51; Ushio-Fukai et al. (1996) *J. Biol. Chem.* 271, 23317-23321), and H_2O_2 in these cells is associated with increased proliferation rate. The occurrence of ROI in a variety of cell types is summarized in Table 1 (adapted from Burdon, R. (1995) *Free Radical Biol. Med.* 18, 775-794).

Table 1

| <u>Superoxide</u> | <u>Hydrogen Peroxide</u> |
|--------------------------------|----------------------------|
| human fibroblasts | Balb/3T3 cells |
| human endothelial cells | rat pancreatic islet cells |
| human/rat smooth muscle cells | murine keratinocytes |
| human fat cells | rabbit chondrocytes |
| human osteocytes | human tumor cells |
| BHK-21 cells | fat cells, 3T3 L1 cells |
| human colonic epithelial cells | |

ROI generated by the neutrophil have a cytotoxic function. While ROI are normally directed at the invading microbe, ROI can also induce tissue damage (e.g., in inflammatory conditions such as arthritis, shock, lung disease, and inflammatory bowel disease) or may be involved in tumor initiation or promotion, due to damaging effects on DNA. Nathan (Szatrowski et al. (1991) *Canc. Res.* 51, 794-798) proposed that the generation of ROI in tumor cells may contribute to the hypermutability seen in tumors, and may therefore contribute to tumor heterogeneity, invasion and metastasis.

In addition to cytotoxic and mutagenic roles, ROI have ideal properties as signal molecules: 1) they are generated in a controlled manner in response to upstream signals; 2) the signal can be terminated by rapid metabolism of O_2^- and H_2O_2 by SOD and catalase/oxidases; 3) they elicit downstream effects on target molecules, e.g., redox-sensitive regulatory proteins such as NF kappa B and AP-1 (Schreck et al. (1991) *EMBO J.* 10, 2247-2258; Schmidt et al. (1995) *Chemistry & Biology* 2, 13-22). Oxidants such as O_2^- and H_2O_2 have a relatively well defined signaling role in bacteria, operating via the SoxI/II regulon to regulate transcription.

ROI appear to have a direct role in regulating cell division, and may function as mitogenic signals in pathological conditions related to growth. These conditions include cancer and cardiovascular disease. O_2^- is generated in endothelial cells

in response to cytokines, and might play a role in angiogenesis (Matsubara et al. (1986) *J. Immun.* 137, 3295-3298). O_2^- and H_2O_2 are also proposed to function as "life-signals", preventing cells from undergoing apoptosis (Matsubara et al. (1986) *J. Immun.* 137, 3295-3298). As discussed above, many cells respond to growth factors (e.g., platelet derived growth factor (PDGF), epidermal derived growth factor (EGF), angiotensin II, and various cytokines) with both increased production of O_2^- / H_2O_2 and increased proliferation. Inhibition of ROI generation prevents the mitogenic response. Exposure to exogenously generated O_2^- and H_2O_2 results in an increase in cell proliferation. A partial list of responsive cell types is shown below in Table 2 (adapted from Burdon, R. (1995) *Free Radical Biol. Med.* 18, 775-794).

Table 2

| <u>Superoxide</u> | <u>Hydrogen peroxide</u> |
|----------------------------------|----------------------------------|
| human, hamster fibroblasts | mouse osteoblastic cells |
| Balb/3T3 cells | Balb/3T3 cells |
| human histiocytic leukemia | rat, hamster fibroblasts |
| mouse epidermal cells | human smooth muscle cells |
| rat colonic epithelial cells | rat vascular smooth muscle cells |
| rat vascular smooth muscle cells | |

While non-transformed cells can respond to growth factors and cytokines with the production of ROI, tumor cells appear to produce ROI in an uncontrolled manner. A series of human tumor cells produced large amounts of hydrogen peroxide compared with non-tumor cells (Szatrowski et al. (1991) *Canc. Res.* 51, 794-798). Ras-transformed NIH 3T3 cells generated elevated amounts of superoxide, and inhibition of superoxide generation by several mechanisms resulted in a reversion to a "normal" growth phenotype.

O_2^- has been implicated in maintenance of the transformed phenotype in cancer cells including melanoma, breast carcinoma, fibrosarcoma, and virally transformed tumor

cells. Decreased levels of the manganese form of SOD (MnSOD) have been measured in cancer cells and *in vitro*-transformed cell lines, predicting increased O_2^- levels (Burdon, R. (1995) *Free Radical Biol. Med.* 18, 775-794). MnSOD is encoded on chromosome 6q25 which is very often lost in melanoma. Overexpression of MnSOD in melanoma and other cancer cells (Church et al. (1993) *Proc. of Natl. Acad. Sci.* 90, 3113-3117; Fernandez-Pol et al. (1982) *Canc. Res.* 42, 609-617; Yan et al. (1996) *Canc. Res.* 56, 2864-2871) resulted in suppression of the transformed phenotype.

ROI are implicated in growth of vascular smooth muscle associated with hypertension, atherosclerosis, and restenosis after angioplasty. O_2^- generation is seen in rabbit aortic adventitia (Pagano et al. (1997) *Proc. Natl. Acad. Sci.* 94, 14483-14488). Vascular endothelial cells release O_2^- in response to cytokines (Matsubara et al. (1986) *J. Immun.* 137, 3295-3298). O_2^- is generated by aortic smooth muscle cells in culture, and increased O_2^- generation is stimulated by angiotensin II which also induces cell hypertrophy. In a rat model system, infusion of angiotensin II leads to hypertension as well as increased O_2^- generation in subsequently isolated aortic tissue (Ushio-Fukai et al. (1996) *J. Biol. Chem.* 271, 23317-23321.; Yu et al. (1997) *J. Biol. Chem.* 272, 27288-27294). Intravenous infusion of a form of SOD that localizes to the vasculature or an infusion of an O_2^- scavenger prevented angiotensin II induced hypertension and inhibited ROI generation (Fukui et al. (1997) *Circ. Res.* 80, 45-51).

The neutrophil NADPH oxidase, also known as phagocyte respiratory burst oxidase, provides a paradigm for the study of the specialized enzymatic ROI-generating system. This extensively studied enzyme oxidizes NADPH and reduces oxygen to form O_2^- . NADPH oxidase consists of multiple proteins and is regulated by assembly of cytosolic and membrane components. The catalytic moiety consists of flavocytochrome b_{558} , an integral plasma membrane enzyme comprised of two components: gp91phox (gp refers to

glycoprotein; phox is an abbreviation of the words phagocyte and oxidase) and p22phox (p refers to protein). gp91phox contains 1 flavin adenine dinucleotide (FAD) and 2 hemes as well as the NADPH binding site. p22phox has a C-terminal
5 proline-rich sequence which serves as a binding site for cytosolic regulatory proteins. The two cytochrome subunits, gp91phox and p22phox appear to stabilize one another, since the genetic absence of either subunit, as in the inherited disorder chronic granulomatous disease (CGD), results in the absence of
10 the partner subunit (Yu et al. (1997) *J. Biol. Chem.* 272, 27288-27294). Essential cytosolic proteins include p47phox, p67phox and the small GTPase Rac, of which there are two isoforms. p47phox and p67phox both contain SH₃ regions and proline-rich regions which participate in protein interactions
15 governing assembly of the oxidase components during activation. The neutrophil enzyme is regulated in response to bacterial phagocytosis or chemotactic signals by phosphorylation of p47phox, and perhaps other components, as well as by guanine nucleotide exchange to activate the GTP-binding protein Rac.
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The origin of ROI in non-phagocytic tissues is unproven, but the occurrence of phagocyte oxidase components has been evaluated in several systems by immunochemical methods, Northern blots and reverse transcriptase-polymerase
25 chain reaction (RT-PCR). The message for p22phox is expressed widely, as is that for Rac1. Several cell types that are capable of O₂⁻ generation have been demonstrated to contain all of the phox components including gp91phox, as summarized below in Table 3. These cell types include endothelial cells,
30 aortic adventitia and lymphocytes.

Table 3

| | Tissue | gp91phox | p22phox | p47phox | p67phox |
|----|----------------------------|------------------|------------------|------------------|------------------|
| | neutrophil | + ^{1,2} | + ^{1,2} | + ^{1,2} | + ^{1,2} |
| | aortic adventitia | + ¹ | + ¹ | + ¹ | + ¹ |
| 5 | lymphocytes | + ² | + ² | + ^{1,2} | + ^{1,2} |
| | endothelial cells | + ² | + ² | + ^{1,2} | + ^{1,2} |
| | glomerular mesangial cells | - | + ^{1,2} | + ^{1,2} | + ^{1,2} |
| | fibroblasts | - | + ² | + ^{1,2} | + ² |
| 10 | aortic sm. muscle | - | + ^{1,2} | ? | ? |

1= protein expression shown. 2= mRNA expression shown.

15 However, a distinctly different pattern is seen in several other cell types shown in Table 3 including glomerular mesangial cells, rat aortic smooth muscle and fibroblasts. In these cells, expression of gp91phox is absent while p22phox and in some cases cytosolic phox components have been demonstrated to be present. Since gp91phox and p22phox stabilize one another in the neutrophil, there has been much speculation that some molecule, possibly related to gp91phox, accounts for ROI generation in glomerular mesangial cells, rat aortic smooth muscle and fibroblasts (Ushio-Fukai et al. (1996) *J. Biol. Chem.* 271, 23317-23321). Investigation of fibroblasts from a patient with a genetic absence of gp91phox provides proof that the gp91phox subunit is not involved in ROI generation in these cells (Emmendorffer et al. (1993) *Eur. J. Haematol.* 51, 223-227). Depletion of p22phox from vascular smooth muscle using an antisense approach indicated that this subunit participates in ROI generation in these cells, despite the absence of detectable gp91phox (Ushio-Fukai et al. (1996) *J. Biol. Chem.* 271, 23317-23321). At this time the molecular candidates possibly related to gp91phox and involved in ROI generation in these cells are unknown.

35 Accordingly, what is needed is the identity of the proteins involved in ROI generation, especially in non-phagocytic tissues and cells. What is also needed are the

5 nucleotide sequences encoding for these proteins, and the primary sequences of the proteins themselves. Also needed are vectors designed to include nucleotides encoding for these proteins. Probes and PCR primers derived from the nucleotide
10 sequence are needed to detect, localize and measure nucleotide sequences, including mRNA, involved in the synthesis of these proteins. In addition, what is needed is a means to transfect cells with these vectors. What is also needed are expression systems for production of these molecules. Also needed are
15 antibodies directed against these molecules for a variety of uses including localization, detection, measurement and passive immunization.

SUMMARY OF THE INVENTION

15 The present invention solves the problems described above by providing a novel family of nucleotide sequences and proteins encoded by these nucleotide sequences termed mox proteins and duox proteins. In particular the present invention provides compositions comprising the
20 nucleotide sequences SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, SEQ ID NO:47, and fragments thereof, which encode for the expression of proteins comprising SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48, respectively, and
25 fragments thereof. While not wanting to be bound by the following statement, it is believed that these proteins are involved in ROI production. The present invention also provides vectors containing these nucleotide sequences, cells transfected with these vectors which produce the proteins
30 comprising SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48, and fragments thereof, and antibodies to these proteins and fragments thereof. The present invention also provides methods for stimulating cellular proliferation by administering vectors encoded for
35 production of the proteins comprising SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 and fragments thereof. The present invention also

provides methods for stimulating cellular proliferation by administering the proteins comprising SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 and fragments thereof. The nucleotides and antibodies of the present invention are useful for the detection, localization and measurement of the nucleic acids encoding for the production of the proteins of the present invention, and also for the detection, localization and measurement of the proteins of the present invention. These nucleotides and antibodies can be combined with other reagents in kits for the purposes of detection, localization and measurement.

Most particularly, the present invention involves a method for regulation of cell division or cell proliferation by modifying the activity or expression of the proteins described as SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 or fragments thereof. These proteins, in their naturally occurring or expressed forms, are expected to be useful in drug development, for example for screening of chemical and drug libraries by observing inhibition of the activity of these enzymes. Such chemicals and drugs would likely be useful as treatments for cancer, prostatic hypertrophy, benign prostatic hypertrophy, hypertension, atherosclerosis and many other disorders involving abnormal cell growth or proliferation as described below. The entire expressed protein may be useful in these assays. Portions of the molecule which may be targets for inhibition or modification include but are not limited to the binding site for pyridine nucleotides (NADPH or NADH), the flavoprotein domain (approximately the C-terminal 265 amino acids), and/or the binding or catalytic site for flavin adenine dinucleotide (FAD).

The method of the present invention may be used for the development of drugs or other therapies for the treatment of conditions associated with abnormal growth including, but not limited to the following: cancer, psoriasis, prostatic hypertrophy, benign prostatic hypertrophy, cardiovascular disease, proliferation of vessels, including but

not limited to blood vessels and lymphatic vessels, arteriovenous malformation, vascular problems associated with the eye, atherosclerosis, hypertension, and restenosis following angioplasty. The enzymes of the present invention are excellent
5 targets for the development of drugs and other agents which may modulate the activity of these enzymes. It is to be understood that modulation of activity may result in enhanced, diminished or absence of enzymatic activity. Modulation of the activity of these enzymes may be useful in treatment of
10 conditions associated with abnormal growth.

Drugs which affect the activity of the enzymes represented in SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48, or fragments thereof, may also be combined with other therapeutics in the
15 treatment of specific conditions. For example, these drugs may be combined with angiogenesis inhibitors in the treatment of cancer, with antihypertensives for the treatment of hypertension, and with cholesterol lowering drugs for the treatment of atherosclerosis.

Accordingly, an object of the present invention is to provide nucleotide sequences, or fragments thereof, encoding for the production of proteins, or fragments thereof, that are involved in ROI production.
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Another object of the present invention is to provide vectors containing these nucleotide sequences, or fragments thereof.
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Yet another object of the present invention is to provide cells transfected with these vectors.

Still another object of the present invention is to administer cells transfected with these vectors to animals and humans.
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Another object of the present invention is to provide proteins, or fragments thereof, that are involved in ROI production.

Still another object of the present invention is to provide antibodies, including monoclonal and polyclonal
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antibodies, or fragments thereof, raised against proteins, or fragments thereof, that are involved in ROI production.

5 Another object of the present invention is to administer genes containing nucleotide sequences, or fragments thereof, encoding for the production of proteins, or fragments thereof, that are involved in ROI production, to animals and humans and also to cells obtained from animals and humans.

10 Another object of the present invention is to administer antisense complimentary sequences of genes containing nucleotide sequences, or fragments thereof, encoding for the production of proteins, or fragments thereof, that are involved in ROI production, to animals and humans and also to cells obtained from animals and humans.

15 Yet another object of the present invention is to provide a method for stimulating or inhibiting cellular proliferation by administering vectors containing nucleotide sequences, or fragments thereof, encoding for the production of proteins, or fragments thereof, that are involved in ROI production, to animals and humans. It is also an object of the
20 present invention to provide a method for stimulating or inhibiting cellular proliferation by administering vectors containing antisense complimentary sequences of nucleotide sequences, or fragments thereof, encoding for the production of proteins, or fragments thereof, that are involved in ROI
25 production, to animals and humans. These methods of stimulating cellular proliferation are useful for a variety of purposes, including but not limited to, developing animal models of tumor formation, stimulating cellular proliferation of blood marrow cells following chemotherapy or radiation, or in
30 cases of anemia.

Still another object of the present invention is to provide antibodies useful in immunotherapy against cancers expressing the proteins represented in SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ
35 ID NO:48 or fragments thereof.

Yet another object of the present invention is to provide nucleotide probes useful for the detection, localization and measurement of nucleotide sequences, or fragments thereof, encoding for the production of proteins, or fragments thereof, that are involved in ROI production.

Another object of the present invention is to provide antibodies useful for the detection, localization and measurement of nucleotide sequences, or fragments thereof, encoding for the production of proteins, or fragments thereof, that are involved in ROI production.

Another object of the present invention is to provide kits useful for detection of nucleic acids including the nucleic acids represented in SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, SEQ ID NO:47, or fragments thereof, that encode for proteins, or fragments thereof, that are involved in ROI production.

Yet another object of the present invention is to provide kits useful for detection and measurement of nucleic acids including the nucleic acids represented in SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, SEQ ID NO:47, or fragments thereof, that encode for proteins, or fragments thereof, that are involved in ROI production.

Still another object of the present invention is to provide kits useful for the localization of nucleic acids including the nucleic acids represented in SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, SEQ ID NO:47, or fragments thereof, that encode for proteins, or fragments thereof that are involved in ROI production.

Another object of the present invention is to provide kits useful for detection of proteins, including the proteins represented in SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48, or fragments thereof, that are involved in ROI production.

Yet another object of the present invention is to provide kits useful for detection and measurement of proteins,

including the proteins represented in SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48, or fragments thereof, that are involved in ROI production.

5 Still another object of the present invention is to provide kits useful for localization of proteins, including the proteins represented in SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48, or fragments thereof, that are involved in ROI production.

10 Yet another object of the present invention is to provides kits useful for the detection, measurement or localization of nucleic acids, or fragments thereof, encoding for proteins, or fragments thereof, that are involved in ROI production, for use in diagnosis and prognosis of abnormal cellular proliferation related to ROI production.

15 Another object of the present invention is to provides kits useful for the detection, measurement or localization of proteins, or fragments thereof, that are involved in ROI production, for use in diagnosis and prognosis of abnormal cellular proliferation related to ROI production.

20 These and other objects, features and advantages of the present invention will become apparent after a review of the following detailed description of the disclosed embodiments and the appended drawings.

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BRIEF DESCRIPTION OF THE FIGURES

Fig. 1(a-d). Comparison of amino acid sequences of the human mox1 protein (labeled mox1.human, SEQ ID NO:2), rat mox1 protein (labeled mox1.rat, SEQ ID NO:21), human mox2 protein (labeled mox2.human., SEQ ID NO:4) of the present invention to human (gp 91phox/human.pep, SEQ ID NO:12) bovine (gp 91 phox/bovine.pep, SEQ ID NO:37), and murine (gp 91 phox/mouse.pep, SEQ ID NO:38) proteins. Also included are related plant enzyme proteins cytb 558.arabidopsis.pep (SEQ ID NO:39) and cytb558.rice.pep,

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(SEQ ID NO:40). Enclosed in boxes are similar amino acid residues.

5 Fig. 2. Sequence similarities among proteins related to gp91phox including human mox1 (SEQ ID NO:2), human mox2 (SEQ ID NO:4), and rat mox1 (SEQ ID NO:21). The dendrogram indicates the degree of similarity among this family of proteins, and also includes the related plant enzymes.

10 Fig. 3. Cell free assay for mox-1 activity. Superoxide generation was measured using the chemiluminescent reaction between lucigenin and superoxide in cell lysates from vector control NEF2 and mox1 transfected NIH3T3 cells.

15 Fig. 4. Superoxide generation by human mox1. Reduction of NBT in mox1 transfected and control fibroblasts was measured in the absence (filled bars) or presence (open bars) or superoxide dismutase.

20 Fig. 5. Aconitase (filled bars), lactate dehydrogenase (narrow hatching) and fumarase (broad hatching) were determined in lysates of cells transfected with vector alone (NEF2) or with mox1 (YA26, YA28 and YA212).

DETAILED DESCRIPTION OF THE INVENTION

25 The present invention solves the problems described above by providing a novel family of nucleotide sequences and proteins, encoded by these nucleotide sequences, termed mox proteins and duox proteins. The term "mox" refers to "mitogenic oxidase" while the term "duox" refers to "dual oxidase". In particular, the present invention provides novel compositions comprising the nucleotide sequences SEQ ID
30 NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, SEQ ID NO:47, and fragments thereof, which encode, respectively, for the expression of proteins comprising SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 and fragments thereof.

35 Both the mox and duox proteins described herein have homology to the gp91phox protein involved in ROI

generation, however, the mox and duox proteins comprise a novel and distinct family of proteins. The mox proteins included in the present invention have a molecular weight of approximately 65 kDa as determined by reducing gel electrophoresis and are capable of inducing ROI generation in cells. As described in more detail below, the mox proteins of the present invention also function in the regulation of cell growth, and are therefore implicated in diseases involving abnormal cell growth such as cancer. The present invention describes mox proteins found in human and rat, however, it is likely that the mox family of genes/proteins is widely distributed among multicellular organisms.

The duox proteins described herein are larger than the mox proteins and have three distinct regions: the amino terminal region having homology to peroxidase proteins, the internal region having homology to calmodulin (CAM) proteins and the carboxy-terminal region having homology to mox proteins. Human duox1 is shown in SEQ ID NO:46 and a portion of human duox2 is shown in SEQ ID NO:48. Nucleotides encoding duox1 and duox2 proteins are also shown in SEQ ID NO: 45 and SEQ ID NO:47, respectively. In addition to the human duox proteins, comparison of the sequence of human duox1 and human duox2 with genomic databases using BLAST searching resulted in the identification of two homologs of duox in *C. elegans* (Ce-duox1 and Ce-duox2). *Drosophila* also appears to have at least one duox homolog. Thus, the duox family of genes/proteins is widely distributed among multicellular organisms.

Although not wanting to be bound by the following statement, it is believed that duox1 and duox2 have dual enzymatic functions, catalyzing both the generation of superoxide and peroxidative type reactions. The latter class of reactions utilize hydrogen peroxide as a substrate (and in some cases have been proposed to utilize superoxide as a substrate). Since hydrogen peroxide is generated spontaneously from the dismutation of superoxide, it is believed that the NAD(P)H

oxidase domain generates the superoxide and/or hydrogen peroxide which can then be used as a substrate for the peroxidase domain. In support of this hypothesis, a model for the duox1 protein in *C. elegans* has been developed that has an extracellular N-terminal peroxidase domain, a transmembrane region and a NADPH binding site located on the cytosolic face of the plasma membrane. By analogy with the neutrophil NADPH-oxidase which generates extracellular superoxide, human duox1 is predicted to generate superoxide and its byproduct hydrogen peroxide extracellularly where it can be utilized by the peroxidase domain.

While the ROI generated by duox1 and duox2 may function as does mox1 in regulation of cell growth, the presence of the peroxidase domain is likely to confer additional biological functions. Depending upon the co-substrate, peroxidases can participate in a variety of reactions including halogenation such as the generation of hypochlorous acid (HOCl) by myeloperoxidase and the iodination of tyrosine to form thyroxine by thyroid peroxidase. Peroxidases have also been documented to participate in the metabolism of polyunsaturated fatty acids, and in the chemical modification of tyrosine in collagen (by sea urchin ovoperoxidase). Although not wanting to be bound by this statement, it is believed that the predicted transmembrane nature of duox1 facilitates its function in the formation or modification of extracellular matrix or basement membrane. Since the extracellular matrix plays an important role in tumor cell growth, invasion and metastasis, it is believed that the duox type enzymes play a pathogenic role in such conditions.

In addition to the nucleotide sequences described above, the present invention also provides vectors containing these nucleotide sequences and fragments thereof, cells transfected with these vectors which produce the proteins comprising SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 and fragments thereof, and antibodies to these proteins and fragments thereof.

5 The present invention also provides methods for stimulating cellular proliferation by administering vectors, or cells containing vectors, encoded for production of the proteins comprising SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 and fragments thereof. The nucleotides and antibodies of the present invention are useful for the detection, localization and measurement of the nucleic acids encoding for the production of the proteins of the present invention, and also for the detection, localization and measurement of the proteins of the present invention. These nucleotides and antibodies can be combined with other reagents in kits for the purposes of detection, localization and measurement. These kits are useful for diagnosis and prognosis of conditions involving cellular proliferation associated with production of reactive oxygen intermediates.

10 The present invention solves the problems described above by providing a composition comprising the nucleotide sequence SEQ ID NO:1 and fragments thereof. The present invention also provides a composition comprising the nucleotide sequence SEQ ID NO:3 and fragments thereof. The present invention also provides a composition comprising the nucleotide sequence SEQ ID NO:22 and fragments thereof. The present invention also provides a composition comprising the nucleotide sequence SEQ ID NO:41 and fragments thereof. The present invention also provides a composition comprising the nucleotide sequence SEQ ID NO:45 and fragments thereof. The present invention also provides a composition comprising the nucleotide sequence SEQ ID NO:47 and fragments thereof.

25 The present invention provides a composition comprising the protein SEQ ID NO:2 encoded by the nucleotide sequence SEQ ID NO:1. The present invention provides a composition comprising the protein SEQ ID NO:4 encoded by the nucleotide sequence SEQ ID NO:3. The present invention provides a composition comprising the protein SEQ ID NO:21 encoded by the nucleotide sequence SEQ ID NO:22. The present invention provides a composition comprising the protein

5 SEQ ID NO:42 encoded by the nucleotide sequence SEQ ID NO:41. The present invention provides a composition comprising the protein SEQ ID NO:46 encoded by the nucleotide sequence SEQ ID NO:45. The present invention provides a composition comprising the protein SEQ ID NO:48 encoded by the nucleotide sequence SEQ ID NO:47.

10 The present invention provides a composition comprising the protein SEQ ID NO:2 or fragments thereof, encoded by the nucleotide sequence SEQ ID NO:1 or fragments thereof. The present invention also provides a composition comprising the protein SEQ ID NO:4 or fragments thereof, encoded by the nucleotide sequence SEQ ID NO:3 or fragments thereof. The present invention also provides a composition comprising the protein SEQ ID NO:21 or fragments thereof, encoded by the nucleotide sequence SEQ ID NO:22 or fragments thereof. The present invention also provides a composition comprising the protein SEQ ID NO:42 or fragments thereof, encoded by the nucleotide sequence SEQ ID NO:41 or fragments thereof. The present invention also provides a composition comprising the protein SEQ ID NO:46 or fragments thereof, encoded by the nucleotide sequence SEQ ID NO:45 or fragments thereof. The present invention also provides a composition comprising the protein SEQ ID NO:48 or fragments thereof, encoded by the nucleotide sequence SEQ ID NO:47 or fragments thereof.

25 The present invention also provides vectors containing the nucleotide sequences SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, SEQ ID NO:47 or fragments thereof. The present invention also provides cells transfected with these vectors. In addition, the present invention provides cells stably transfected with the nucleotide sequence SEQ ID NO:1 or fragments thereof. The present invention also provides cells stably transfected with the nucleotide sequence SEQ ID NO:3 or fragments thereof. The present invention also provides cells stably transfected with the nucleotide sequence SEQ ID NO:22 or fragments thereof. The

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present invention also provides cells stably transfected with the nucleotide sequence SEQ ID NO:41 or fragments thereof. The present invention also provides cells stably transfected with the nucleotide sequence SEQ ID NO:45 or fragments thereof. The present invention also provides cells stably transfected with the nucleotide sequence SEQ ID NO:47 or fragments thereof.

The present invention provides cells stably transfected with the nucleotide sequence SEQ ID NO:1 or fragments thereof, which produce the protein SEQ ID NO:2 or fragments thereof. In addition, the present invention provides cells stably transfected with the nucleotide sequence SEQ ID NO:3 or fragments thereof which produce the protein SEQ ID NO:4 or fragments thereof. In addition, the present invention provides cells stably transfected with the nucleotide sequence SEQ ID NO:22 or fragments thereof which produce the protein SEQ ID NO:21 or fragments thereof. The present invention also provides cells stably transfected with the nucleotide sequence SEQ ID NO:41 or fragments thereof which produce the protein SEQ ID NO:42 or fragments thereof. The present invention also provides cells stably transfected with the nucleotide sequence SEQ ID NO:45 or fragments thereof which produce the protein SEQ ID NO:46 or fragments thereof. The present invention also provides cells stably transfected with the nucleotide sequence SEQ ID NO:47 or fragments thereof which produce the protein SEQ ID NO:48 or fragments thereof.

The present invention provides a method for stimulating growth by administering cells stably transfected with the nucleotide sequence SEQ ID NO:1 which produce the protein SEQ ID NO:2 or fragments thereof. The present invention also provides a method for stimulating growth by administering cells stably transfected with the nucleotide sequence SEQ ID NO:3 or fragments thereof, which produce the protein SEQ ID NO:4 or fragments thereof. The present invention also provides a method for stimulating growth by administering cells stably transfected with the nucleotide sequence SEQ ID NO:22 or fragments thereof, which produce

the protein SEQ ID NO:21 or fragments thereof. The present invention also provides a method for stimulating growth by administering cells stably transfected with the nucleotide sequence SEQ ID NO:41 or fragments thereof, which produce the protein SEQ ID NO:42 or fragments thereof. The present invention also provides a method for stimulating growth by administering cells stably transfected with the nucleotide sequence SEQ ID NO:45 or fragments thereof, which produce the protein SEQ ID NO:46 or fragments thereof. The present invention also provides a method for stimulating growth by administering cells stably transfected with the nucleotide sequence SEQ ID NO:47 or fragments thereof, which produce the protein SEQ ID NO:48 or fragments thereof.

Specifically, the present invention provides a method for stimulating tumor formation by administering cells stably transfected with the nucleotide sequence SEQ ID NO:1 or fragments thereof, which produce the protein SEQ ID NO:2 or fragments thereof. The present invention also provides a method for stimulating tumor formation by administering cells stably transfected with the nucleotide sequence SEQ ID NO:3 or fragments thereof, which produce the protein SEQ ID NO:4 or fragments thereof. The present invention also provides a method for stimulating tumor formation by administering cells stably transfected with the nucleotide sequence SEQ ID NO:22 or fragments thereof, which produce the protein SEQ ID NO:21 or fragments thereof. The present invention also provides a method for stimulating tumor formation by administering cells stably transfected with the nucleotide sequence SEQ ID NO:41 or fragments thereof, which produce the protein SEQ ID NO:42 or fragments thereof. The present invention also provides a method for stimulating tumor formation by administering cells stably transfected with the nucleotide sequence SEQ ID NO:45 or fragments thereof, which produce the protein SEQ ID NO:46 or fragments thereof. The present invention also provides a method for stimulating tumor formation by administering cells stably transfected with the nucleotide sequence SEQ ID NO:47

or fragments thereof, which produce the protein SEQ ID NO:48 or fragments thereof.

5 The present invention may also be used to develop anti-sense nucleotide sequences to SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, SEQ ID NO:47 or fragments thereof. These anti-sense molecules may be used to interfere with translation of nucleotide sequences, such as SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, SEQ ID NO:47, or fragments thereof, that encode for proteins such as SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 or fragments thereof. Administration of these anti-sense molecules, or vectors encoding for anti sense molecules, to humans and animals, would interfere with production of proteins such as SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48, or fragments thereof, thereby decreasing production of ROIs and inhibiting cellular proliferation. These methods are useful in producing animal models for use in study of tumor development and vascular growth, and for study of the efficacy of treatments for affecting tumor and vascular growth *in vivo*.

20 The present invention also provides a method for high throughput screening of drugs and chemicals which modulate the proliferative activity of the enzymes of the present invention, thereby affecting cell division. Combinatorial chemical libraries may be screened for chemicals which modulate the proliferative activity of these enzymes. Drugs and chemicals may be evaluated based on their ability to modulate the enzymatic activity of the expressed or endogenous proteins, including those represented by SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 or fragments thereof. Endogenous proteins may be obtained from many different tissues or cells, such as colon cells. Drugs may also be evaluated based on their ability to bind to the expressed or endogenous proteins represented by SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID

NO:46, SEQ ID NO:48 or fragments thereof. Enzymatic activity may be NADPH- or NADH-dependent superoxide generation catalyzed by the holoprotein. Enzymatic activity may also be NADPH- or NADH-dependent diaphorase activity catalyzed by either the holoprotein or the flavoprotein domain.

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By flavoprotein domain, is meant approximately the C-terminal half of the enzymes shown in SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, or fragments thereof, and the C-terminal end of the enzymes shown in SEQ ID NO:46 and SEQ ID NO:48 (approximately the C-terminal 265 amino acids). This fragment of gp91phox has NADPH-dependent reductase activity towards cytochrome c, nitrobluetetrazolium and other dyes. Expressed proteins or fragments thereof can be used for robotic screens of existing combinatorial chemical libraries. While not wanting to be bound by the following statement, it is believed that the NADPH or NADH binding site and the FAD binding site are useful for evaluating the ability of drugs and other compositions to bind to the mox and duox enzymes or to modulate their enzymatic activity. The use of the holoprotein or the C-terminal half or end regions are preferred for developing a high throughput drug screen. Additionally, the N-terminal one-third of the duox domain (the peroxidase domain) may also be used to evaluate the ability of drugs and other compositions to inhibit the peroxidase activity, and for further development of a high throughput drug screen.

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The present invention also provides antibodies directed to the proteins SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 and fragments thereof. The antibodies of the present invention are useful for a variety of purposes including localization, detection and measurement of the proteins SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 and fragments thereof. The antibodies may be employed in kits to accomplish these purposes. These antibodies may also be linked to cytotoxic agents for selected killing of cells. The

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term antibody is meant to include any class of antibody such as IgG, IgM and other classes. The term antibody also includes a completely intact antibody and also fragments thereof, including but not limited to Fab fragments and Fab + Fc fragments.

5 The present invention also provides the nucleotide sequences SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, SEQ ID NO:47 and fragments thereof. These nucleotides are useful for a variety of purposes including localization, detection, and measurement of messenger
10 RNA involved in synthesis of the proteins represented as SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 and fragments thereof. These nucleotides may also be used in the construction of labeled probes for the localization, detection, and measurement of
15 nucleic acids such as messenger RNA or alternatively for the isolation of larger nucleotide sequences containing the nucleotide sequences shown in SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, SEQ ID NO:47 or fragments thereof. These nucleotide sequences may
20 be used to isolate homologous strands from other species using techniques known to one of ordinary skill in the art. These nucleotide sequences may also be used to make probes and complementary strands. In particular, the nucleotide sequence shown in SEQ ID NO:47 may be used to isolate the complete
25 coding sequence for duox2. The nucleotides may be employed in kits to accomplish these purposes.

 Most particularly, the present invention involves a method for modulation of growth by modifying the proteins represented as SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21,
30 SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 or fragments thereof.

 The term "mitogenic regulators" is used herein to mean any molecule that acts to affect cell division.

 The term "animal" is used herein to mean humans
35 and non-human animals of both sexes.

The terms "a", "an" and "the" as used herein are defined to mean one or more and include the plural unless the context is inappropriate.

5 "Proteins", "peptides," "polypeptides" and "oligopeptides" are chains of amino acids (typically L-amino acids) whose alpha carbons are linked through peptide bonds formed by a condensation reaction between the carboxyl group of the alpha carbon of one amino acid and the amino group of the alpha carbon of another amino acid. The terminal amino
10 acid at one end of the chain (*i.e.*, the amino terminal) has a free amino group, while the terminal amino acid at the other end of the chain (*i.e.*, the carboxy terminal) has a free carboxyl group. As such, the term "amino terminus" (abbreviated N-terminus) refers to the free alpha-amino group on the amino acid at the
15 amino terminal of the protein, or to the alpha-amino group (imino group when participating in a peptide bond) of an amino acid at any other location within the protein. Similarly, the term "carboxy terminus" (abbreviated C-terminus) refers to the free carboxyl group on the amino acid at the carboxy terminus
20 of a protein, or to the carboxyl group of an amino acid at any other location within the protein.

Typically, the amino acids making up a protein are numbered in order, starting at the amino terminal and increasing in the direction toward the carboxy terminal of the
25 protein. Thus, when one amino acid is said to "follow" another, that amino acid is positioned closer to the carboxy terminal of the protein than the preceding amino acid.

The term "residue" is used herein to refer to an amino acid (D or L) or an amino acid mimetic that is
30 incorporated into a protein by an amide bond. As such, the amino acid may be a naturally occurring amino acid or, unless otherwise limited, may encompass known analogs of natural amino acids that function in a manner similar to the naturally occurring amino acids (*i.e.*, amino acid mimetics). Moreover,
35 an amide bond mimetic includes peptide backbone modifications well known to those skilled in the art.

Furthermore, one of skill will recognize that, as mentioned above, individual substitutions, deletions or additions which alter, add or delete a single amino acid or a small percentage of amino acids (typically less than 5%, more typically less than 1%) in an encoded sequence are conservatively modified variations where the alterations result in the substitution of an amino acid with a chemically similar amino acid. Conservative substitution tables providing functionally similar amino acids are well known in the art. The following six groups each contain amino acids that are conservative substitutions for one another:

- 1) Alanine (A), Serine (S), Threonine (T);
- 2) Aspartic acid (D), Glutamic acid (E);
- 3) Asparagine (N), Glutamine (Q);
- 4) Arginine (R), Lysine (K);
- 5) Isoleucine (I), Leucine (L), Methionine (M), Valine (V); and
- 6) Phenylalanine (F), Tyrosine (Y), Tryptophan (W).

When the peptides are relatively short in length (*i.e.*, less than about 50 amino acids), they are often synthesized using standard chemical peptide synthesis techniques. Solid phase synthesis in which the C-terminal amino acid of the sequence is attached to an insoluble support followed by sequential addition of the remaining amino acids in the sequence is a preferred method for the chemical synthesis of the antigenic epitopes described herein. Techniques for solid phase synthesis are known to those skilled in the art.

Alternatively, the antigenic epitopes described herein are synthesized using recombinant nucleic acid methodology. Generally, this involves creating a nucleic acid sequence that encodes the peptide or protein, placing the nucleic acid in an expression cassette under the control of a particular promoter, expressing the peptide or protein in a host, isolating the expressed peptide or protein and, if required, renaturing the

peptide or protein. Techniques sufficient to guide one of skill through such procedures are found in the literature.

When several desired protein fragments or peptides are encoded in the nucleotide sequence incorporated into a vector, one of skill in the art will appreciate that the protein fragments or peptides may be separated by a spacer molecule such as, for example, a peptide, consisting of one or more amino acids. Generally, the spacer will have no specific biological activity other than to join the desired protein fragments or peptides together, or to preserve some minimum distance or other spatial relationship between them. However, the constituent amino acids of the spacer may be selected to influence some property of the molecule such as the folding, net charge, or hydrophobicity. Nucleotide sequences encoding for the production of residues which may be useful in purification of the expressed recombinant protein may be built into the vector. Such sequences are known in the art. For example, a nucleotide sequence encoding for a poly histidine sequence may be added to a vector to facilitate purification of the expressed recombinant protein on a nickel column.

Once expressed, recombinant peptides, polypeptides and proteins can be purified according to standard procedures known to one of ordinary skill in the art, including ammonium sulfate precipitation, affinity columns, column chromatography, gel electrophoresis and the like. Substantially pure compositions of about 50 to 99% homogeneity are preferred, and 80 to 95% or greater homogeneity are most preferred for use as therapeutic agents.

One of skill in the art will recognize that after chemical synthesis, biological expression or purification, the desired proteins, fragments thereof and peptides may possess a conformation substantially different than the native conformations of the proteins, fragments thereof and peptides. In this case, it is often necessary to denature and reduce protein and then to cause the protein to re-fold into the preferred conformation. Methods of reducing and denaturing proteins

and inducing re-folding are well known to those of skill in the art.

5 The genetic constructs of the present invention include coding sequences for different proteins, fragments thereof, and peptides. The genetic constructs also include epitopes or domains chosen to permit purification or detection of the expressed protein. Such epitopes or domains include DNA sequences encoding the glutathione binding domain from glutathione S-transferase, hexa-histidine, thioredoxin, 10 hemagglutinin antigen, maltose binding protein, and others commonly known to one of skill in the art. The preferred genetic construct includes the nucleotide sequences of SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, SEQ ID NO:47 or fragments thereof. It is to be understood that additional or alternative nucleotide sequences may be included in the genetic constructs in order to encode for the following: a) multiple copies of the desired proteins, fragments thereof, or peptides; b) various combinations of the desired proteins, fragments thereof, or peptides; and c) 20 conservative modifications of the desired proteins, fragments thereof, or peptides, and combinations thereof. Preferred proteins include the human mox1 protein and human mox2 protein shown as SEQ ID NO:2 and SEQ ID NO:4, respectively, and fragments thereof. Some preferred fragments of the human mox1 protein (SEQ ID NO:2) include but are not limited to the proteins shown as SEQ ID NO:23, SEQ ID NO:24, and SEQ ID NO:25. The protein mox1 is also called p65mox in this application. Another preferred protein of the present invention is rat mox1 protein shown as SEQ ID NO:21 and fragments thereof. Another preferred protein of the present invention is rat mox1B protein shown as SEQ ID NO:42 and fragments thereof. Yet another preferred protein of the present invention is duox1 protein shown as SEQ ID NO:46 and fragments thereof. Still another preferred protein of the present invention is duox2 protein. A partial amino acid sequence of the duox2 protein is shown as SEQ ID NO:48.

5 The nucleotide sequences of the present invention may also be employed to hybridize to nucleic acids such as DNA or RNA nucleotide sequences under high stringency conditions which permit detection, for example, of alternately spliced messages.

10 The genetic construct is expressed in an expression system such as in NIH 3T3 cells using recombinant sequences in a pcDNA-3 vector (Invitrogen, Carlsbad, CA) to produce a recombinant protein. Preferred expression systems include but are not limited to Cos-7 cells, insect cells using recombinant baculovirus, and yeast. It is to be understood that other expression systems known to one of skill in the art may be used for expression of the genetic constructs of the present invention. The preferred proteins of the present invention are the proteins referred to herein as human mox1 and human mox2 or fragments thereof which have the amino acid sequences set forth in SEQ ID NO:3 and SEQ ID NO:4, respectively, or an amino acid sequence having amino acid substitutions as defined in the definitions that do not significantly alter the function of the recombinant protein in an adverse manner. Another preferred protein of the present invention is referred to herein as rat mox1 and has the amino acid sequence set forth in SEQ ID NO:21. Yet another preferred protein of the present invention is referred to herein as rat mox1B and has the amino acid sequence set forth in SEQ ID NO:42. Two other preferred proteins of the present invention are referred to herein as human duox1 and human duox2, or fragments thereof, which have the amino acid sequences set forth in SEQ ID NO:46 and SEQ ID NO:48, respectively, or an amino acid sequence having amino acid substitutions as defined in the definitions that do not significantly alter the function of the recombinant protein in an adverse manner.

Terminology

35 It should be understood that some of the terminology used to describe the novel mox and duox proteins

5 contained herein is different from the terminology in U.S. Provisional Application Serial No. 60/107,911 and U.S. Provisional Application Serial No. 60/149,332 upon which this application claims priority in part. As described herein, the term "human mox1" refers to a protein comprising an amino acid sequence as set forth in SEQ ID NO:2, or a fragment thereof, and encoded by the nucleotide sequence as set forth in SEQ ID NO:1, or a fragment thereof. As described herein, the term "human mox2" refers to a protein comprising an amino acid sequence as set forth in SEQ ID NO:4, or a fragment thereof, and encoded by the nucleotide sequence as set forth in SEQ ID NO:3, or a fragment thereof. As described herein, the term "human duox1" refers to a protein comprising an amino acid sequence as set forth in SEQ ID NO:46, or a fragment thereof, and encoded by the nucleotide sequence as set forth in SEQ ID NO:45, or a fragment thereof. As described herein, the term "human duox2" refers to a protein comprising an amino acid sequence as set forth in SEQ ID NO:48, or a fragment thereof, and encoded by the nucleotide sequence as set forth in SEQ ID NO:47, or a fragment thereof.

Construction of the Recombinant Gene

25 The desired gene is ligated into a transfer vector, such as pcDNA3, and the recombinants are used to transform host cells such as Cos-7 cells. It is to be understood that different transfer vectors, host cells, and transfection methods may be employed as commonly known to one of ordinary skill in the art. Six desired genes for use in transfection are shown in SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41 SEQ ID NO:45 and SEQ ID NO:47. For example, lipofectamine-mediated transfection and *in vivo* homologous recombination was used to introduce the mox1 gene into NIH 3T3 cells.

35 The synthetic gene is cloned and the recombinant construct containing mox or duox gene is produced and grown in confluent monolayer cultures of a Cos-7 cell line. The

expressed recombinant protein is then purified, preferably using affinity chromatography techniques, and its purity and specificity determined by known methods.

5 A variety of expression systems may be employed for expression of the recombinant protein. Such expression methods include, but are not limited to the following: bacterial expression systems, including those utilizing *E. coli* and *Bacillus subtilis*; virus systems; yeast expression systems; cultured insect and mammalian cells; and other expression systems known to
10 one of ordinary skill in the art.

Transfection of Cells

It is to be understood that the vectors of the present invention may be transfected into any desired cell or cell line.
15 Both *in vivo* and *in vitro* transfection of cells are contemplated as part of the present invention. Preferred cells for transfection include but are not limited to the following: fibroblasts (possibly to enhance wound healing and skin formation), granulocytes (possible benefit to increase function in a
20 compromised immune system as seen in AIDS, and aplastic anemia), muscle cells, neuroblasts, stem cells, bone marrow cells, osteoblasts, B lymphocytes, and T lymphocytes.

Cells may be transfected with a variety of methods known to one of ordinary skill in the art and include but are not
25 limited to the following: electroporation, gene gun, calcium phosphate, lipofectamine, and fugene, as well as adenoviral transfection systems.

Host cells transfected with the nucleic acids represented in SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22,
30 SEQ ID NO:41 SEQ ID NO:45 and SEQ ID NO:47, or fragments thereof, are used to express the proteins SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46 and SEQ ID NO:48, respectively, or fragments thereof.

These expressed proteins are used to raise
35 antibodies. These antibodies may be used for a variety of applications including but not limited to immunotherapy against

cancers expressing one of the mox or duox proteins, and for detection, localization and measurement of the proteins shown in SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46 or SEQ ID NO:48 or fragments thereof.

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Purification and Characterization of the Expressed Protein

The proteins of the present invention can be expressed as a fusion protein with a poly histidine component, such as a hexa histidine, and purified by binding to a metal affinity column using nickel or cobalt affinity matrices. The protein can also be expressed as a fusion protein with glutathione S-transferase and purified by affinity chromatography using a glutathione agarose matrix. The protein can also be purified by immunoaffinity chromatography by expressing it as a fusion protein, for example with hemagglutinin antigen. The expressed or naturally occurring protein can also be purified by conventional chromatographic and purification methods which include anion and cation exchange chromatography, gel exclusion chromatography, hydroxylapatite chromatography, dye binding chromatography, ammonium sulfate precipitation, precipitation in organic solvents or other techniques commonly known to one of skill in the art.

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Methods of Assessing Activity of Expressed Proteins

Different methods are available for assessing the activity of the expressed proteins of the present invention, including but not limited to the proteins represented as SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46 or SEQ ID NO:48 substituted analogs thereof, and fragments thereof.

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1. Assays of the holoprotein and fragments thereof for superoxide generation:

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A. General considerations.

These assays are useful in assessing efficacy of drugs designed to modulate the activity of the enzymes of the present invention. The holoprotein may be expressed in COS-7 cells, NIH 3T3 cells, insect cells (using baculoviral technology) or other cells using methods known to one of skill in the art. Membrane fractions or purified protein are used for the assay. The assay may require or be augmented by other cellular proteins such as p47phox, p67phox, and Rac1, as well as potentially other unidentified factors (e.g., kinases or other regulatory proteins).

B. Cytochrome c reduction.

NADPH or NADH is used as the reducing substrate, in a concentration of about 100 μ M. Reduction of cytochrome c is monitored spectrophotometrically by the increase in absorbance at 550 nm, assuming an extinction coefficient of 21 $\text{mM}^{-1}\text{cm}^{-1}$. The assay is performed in the absence and presence of about 10 μ g superoxide dismutase. The superoxide-dependent reduction is defined as cytochrome c reduction in the absence of superoxide dismutase minus that in the presence of superoxide dismutase (Uhlinger et al. (1991) *J. Biol. Chem.* 266, 20990-20997). Acetylated cytochrome c may also be used, since the reduction of acetylated cytochrome c is thought to be exclusively via superoxide.

C. Nitroblue tetrazolium reduction.

For nitroblue tetrazolium (NBT) reduction, the same general protocol is used, except that NBT is used in place of cytochrome c. In general, about 1 mL of filtered 0.25 % nitrotetrazolium blue (Sigma, St. Louis, MO) is added in Hanks buffer without or with about 600 Units of superoxide dismutase (Sigma) and samples are incubated at approximately 37°C. The oxidized NBT is clear, while the reduced NBT is blue and insoluble. The insoluble product is collected by centrifugation, and the pellet is re-suspended in about 1 mL of pyridine (Sigma) and heated for about 10 minutes at 100°C to solubilize

the reduced NBT. The concentration of reduced NBT is determined by measuring the absorbance at 510 nm, using an extinction coefficient of $11,000 \text{ M}^{-1}\text{cm}^{-1}$. Untreated wells are used to determine cell number.

5

D. Luminescence.

Superoxide generation may also be monitored with a chemiluminescence detection system utilizing lucigenin (bis-N-methylacridinium nitrate, Sigma, St. Louis, MO). The sample is mixed with about $100 \mu\text{M}$ NADPH (Sigma, St. Louis, MO) and $10 \mu\text{M}$ lucigenin (Sigma, St. Louis, MO) in a volume of about $150 \mu\text{L}$ Hanks solution. Luminescence is monitored in a 96-well plate using a LumiCounter (Packard, Downers Grove, IL) for 0.5 second per reading at approximately 1 minute intervals for a total of about 5 minutes; the highest stable value in each data set is used for comparisons. As above, superoxide dismutase is added to some samples to prove that the luminescence arises from superoxide. A buffer blank is subtracted from each reading (Ushio-Fukai et al. (1996) *J. Biol. Chem.* 271, 23317-23321).

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E. Assays in intact cells.

Assays for superoxide generation may be performed using intact cells, for example, the mox-transfected NIH 3T3 cells. In principle, any of the above assays can be used to evaluate superoxide generation using intact cells, for example, the mox-transfected NIH 3T3 cells. NBT reduction is a preferred assay method.

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2. Assays of truncated proteins comprised of approximately the C-terminal 265 amino acid residues

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While not wanting to be bound by the following statement, the truncated protein comprised of approximately the C-terminal 265 amino acid residues is not expected to generate superoxide, and therefore, superoxide dismutase is not added in assays of the truncated protein. Basically, a similar assay is

established and the superoxide-independent reduction of NBT, cytochrome c, dichlorophenolindophenol, ferricyanide, or another redox-active dye is examined.

5 *Nucleotides and Nucleic Acid Probes*

10 The nucleotide sequences SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41 SEQ ID NO:45 and SEQ ID NO:47, as well as fragments thereof and PCR primers therefor, may be used, respectively, for localization, detection and measurement of nucleic acids related to SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41 SEQ ID NO:45 and SEQ ID NO:47, as well as fragments thereof. The nucleotide sequences SEQ ID NO:1 and SEQ ID NO:3 are also called the human mox1 gene and the human mox2 gene in this application. SEQ ID NO:22 is also known as the rat mox1 gene in this application. SEQ ID NO:41 is also known as the rat mox1B gene in this application. SEQ ID NO:45 is also known as the human duox1 gene in this application. SEQ ID NO:47 is also known as the human duox2 gene in this application.

20 The nucleotide sequences SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41 SEQ ID NO:45 and SEQ ID NO:47, as well as fragments thereof, may be used to create probes to isolate larger nucleotide sequences containing the nucleotide sequences SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41 SEQ ID NO:45 and SEQ ID NO:47, respectively. The nucleotide sequences SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41 SEQ ID NO:45 and SEQ ID NO:47, as well as fragments thereof, may also be used to create probes to identify and isolate mox and duox proteins in other species.

30 The nucleic acids described herein include messenger RNA coding for production of SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 and fragments thereof. Such nucleic acids include but are not limited to cDNA probes. These probes may be labeled in a variety of ways known to one of ordinary skill in

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the art. Such methods include but are not limited to isotopic and non-isotopic labeling. These probes may be used for *in situ* hybridization for localization of nucleic acids such as mRNA encoding for SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 and fragments thereof. Localization may be performed using *in situ* hybridization at both ultrastructural and light microscopic levels of resolution using techniques known to one of ordinary skill in the art.

These probes may also be employed to detect and quantitate nucleic acids and mRNA levels using techniques known to one of ordinary skill in the art including but not limited to solution hybridization.

Antibody Production

The proteins shown in SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48, or fragments thereof, are combined with a pharmaceutically acceptable carrier or vehicle to produce a pharmaceutical composition and administered to animals for the production of polyclonal antibodies using methods known to one of ordinary skill in the art. The preferred animals for antibody production are rabbits and mice. Other animals may be employed for immunization with these proteins or fragments thereof. Such animals include, but are not limited to the following; sheep, horses, pigs, donkeys, cows, monkeys and rodents such as guinea pigs and rats.

The terms "pharmaceutically acceptable carrier or pharmaceutically acceptable vehicle" are used herein to mean any liquid including but not limited to water or saline, oil, gel, salve, solvent, diluent, fluid ointment base, liposome, micelle, giant micelle, and the like, which is suitable for use in contact with living animal or human tissue without causing adverse physiological responses, and which does not interact with the other components of the composition in a deleterious manner.

5 The pharmaceutical compositions may conveniently be presented in unit dosage form and may be prepared by conventional pharmaceutical techniques. Such techniques include the step of bringing into association the active ingredient and the pharmaceutical carrier(s) or excipient(s). In general, the formulations are prepared by uniformly and intimately bringing into association the active ingredient with liquid carriers.

10 Formulations suitable for parenteral administration include aqueous and non-aqueous sterile injection solutions which may contain anti-oxidants, buffers, bacteriostats and solutes which render the formulation isotonic with the blood of the intended recipient; and aqueous and non-aqueous sterile suspensions which may include suspending agents and thickening agents. The formulations may be presented in unit-dose or multi-dose containers, for example, sealed ampules and vials, and may be stored in a freeze-dried (lyophilized) condition requiring only the addition of the sterile liquid carrier, for example, water for injections, immediately prior to use. 15 Extemporaneous injection solutions and suspensions may be prepared from sterile powders, granules and tablets commonly used by one of ordinary skill in the art.

20 Preferred unit dosage formulations are those containing a dose or unit, or an appropriate fraction thereof, of the administered ingredient. It should be understood that in addition to the ingredients, particularly mentioned above, the formulations of the present invention may include other agents commonly used by one of ordinary skill in the art.

25 The pharmaceutical composition may be administered through different routes, such as oral, including buccal and sublingual, rectal, parenteral, aerosol, nasal, intramuscular, subcutaneous, intradermal, and topical. The pharmaceutical composition of the present invention may be administered in different forms, including but not limited to 30 solutions, emulsions and suspensions, microspheres, particles, microparticles, nanoparticles, and liposomes. It is expected that 35

from about 1 to 7 dosages may be required per immunization regimen. Initial injections may range from about 0.1 μ g to 1 mg, with a preferred range of about 1 μ g to 800 μ g, and a more preferred range of from approximately 25 μ g to 500 μ g. Booster injections may range from 0.1 μ g to 1 mg, with a preferred range of approximately 1 μ g to 800 μ g, and a more preferred range of about 10 μ g to 500 μ g.

The volume of administration will vary depending on the route of administration and the size of the recipient. For example, intramuscular injections may range from about 0.1 ml to 1.0 ml.

The pharmaceutical composition may be stored at temperatures of from about 4°C to -100°C. The pharmaceutical composition may also be stored in a lyophilized state at different temperatures including room temperature. The pharmaceutical composition may be sterilized through conventional means known to one of ordinary skill in the art. Such means include, but are not limited to filtration, radiation and heat. The pharmaceutical composition of the present invention may also be combined with bacteriostatic agents, such as thimerosal, to inhibit bacterial growth.

Adjuvants

A variety of adjuvants known to one of ordinary skill in the art may be administered in conjunction with the protein in the pharmaceutical composition. Such adjuvants include, but are not limited to the following: polymers, copolymers such as polyoxyethylene-polyoxypropylene copolymers, including block co-polymers; polymer P1005; Freund's complete adjuvant (for animals); Freund's incomplete adjuvant; sorbitan monooleate; squalene; CRL-8300 adjuvant; alum; QS 21, muramyl dipeptide; trehalose; bacterial extracts, including mycobacterial extracts; detoxified endotoxins; membrane lipids; or combinations thereof.

Monoclonal antibodies can be produced using hybridoma technology in accordance with methods well known

to those skilled in the art. The antibodies are useful as research or diagnostic reagents or can be used for passive immunization. The composition may optionally contain an adjuvant.

5 The polyclonal and monoclonal antibodies useful as research or diagnostic reagents may be employed for detection and measurement of SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 and fragments thereof. Such antibodies may be used to detect these proteins in a biological sample, including but not limited to
10 samples such as cells, cellular extracts, tissues, tissue extracts, biopsies, tumors, and biological fluids. Such detection capability is useful for detection of disease related to these proteins to facilitate diagnosis and prognosis and to suggest possible treatment alternatives.

15 Detection may be achieved through the use of immunocytochemistry, ELISA, radioimmunoassay or other assays as commonly known to one of ordinary skill in the art. The mox1, mox2, duox1 and duox2 proteins, or fragments thereof, may be labeled through commonly known approaches,
20 including but not limited to the following: radiolabeling, dyes, magnetic particles, biotin-avidin, fluorescent molecules, chemiluminescent molecules and systems, ferritin, colloidal gold, and other methods known to one of skill in the art of labeling proteins.

25 *Administration of Antibodies*

The antibodies directed to the proteins shown as SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46 or SEQ ID NO:48, or directed to fragments
30 thereof, may also be administered directly to humans and animals in a passive immunization paradigm. Antibodies directed to extracellular portions of SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46 or SEQ ID NO:48 bind to these extracellular epitopes. Attachment of
35 labels to these antibodies facilitates localization and visualization of sites of binding. Attachment of molecules such as ricin or

other cytotoxins to these antibodies helps to selectively damage or kill cells expressing SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, SEQ ID NO:48 or fragments thereof.

5

Kits

The present invention includes kits useful with the antibodies, nucleic acids, nucleic acid probes, labeled antibodies, labeled proteins or fragments thereof for detection, localization and measurement of SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:42, SEQ ID NO:45, SEQ ID NO:46, SEQ ID NO:47, SEQ ID NO:48 or combinations and fragments thereof.

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Kits may be used for immunocytochemistry, *in situ* hybridization, solution hybridization, radioimmunoassay, ELISA, Western blots, quantitative PCR, and other assays for the detection, localization and measurement of these nucleic acids, proteins or fragments thereof using techniques known to one of skill in the art.

20

The nucleotide sequences shown in SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41 SEQ ID NO:45, SEQ ID NO:47, or fragments thereof, may also be used under high stringency conditions to detect alternately spliced messages related to SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41 SEQ ID NO:45, SEQ ID NO:47 or fragments thereof, respectively.

25

As discussed in one of the Examples, rat mox1 protein (SEQ ID NO: 21) is similar to mouse gp91 protein (SEQ ID NO: 38), whereas rat mox1B protein (SEQ ID NO:42) is similar to human gp91 protein (SEQ ID NO:12). This observation suggests that other isoforms of mouse and human gp91 may exist. In addition, another subtype of human mox1, similar to rat mox1B (SEQ ID NO:42), also exists. The presence of two isoforms of rat mox1 protein in vascular smooth muscle may have important physiological consequences

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and biomedical applications. For example, the two isoforms may have different biological activities, different tissue distributions and may be regulated differently in physiological and/or pathological conditions. The fact that mox1B (SEQ ID NO:42) was isolated from cells exposed to angiotensin II, known to promote oxidative stress and vascular growth, suggests that it may be upregulated by this hormone and may be overexpressed in disease. Therefore, the diagnostic kits of the present invention can measure the relative expression of the two mox isoforms. The diagnostic kits may also measure or detect the relative expression of the mox proteins described herein (i.e. human mox1 and/or human mox2) and duox proteins described herein (i.e. human duox1 and/or human duox2).

Fragments of SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41 SEQ ID NO:45 and SEQ ID NO:47 containing the relevant hybridizing sequence can be synthesized onto the surface of a chip array. RNA samples, e.g., from tumors, are then fluorescently tagged and hybridized onto the chip for detection. This approach may be used diagnostically to characterize tumor types and to tailor treatments and/or provide prognostic information. Such prognostic information may have predictive value concerning disease progression and life span, and may also affect choice of therapy.

The present invention is further illustrated by the following examples, which are not to be construed in any way as imposing limitations upon the scope thereof. On the contrary, it is to be clearly understood that resort may be had to various other embodiments, modifications, and equivalents thereof, which, after reading the description herein, may suggest themselves to those skilled in the art without departing from the spirit of the present invention.

EXAMPLE 1

Sequence Analysis and Cloning of the Human mox1 cDNA (SEQ ID NO:1) Encoding for Production of the Human mox1 Protein p65mox (SEQ ID NO:2)

5 Using gp91phox as a query sequence, a 334 base sequenced portion of expressed sequence tag (EST) 176696 (GenBank Accession number AA305700) showed 68.8% sequence identity at the predicted amino acid level with human (h) gp91phox. The bacterial strain number 129134 containing the EST sequence in the pBluescript SK⁻ vector, was purchased from American Tissue Type Culture Collection (ATCC, Rockville, MD). The EST sequence was originally cloned from a Caco-2 human colon carcinoma cell line. The EST176696 DNA was further sequenced using the T7 and T3 vector promoters and primers designed to match the known 3' sequence. Internal primers used for sequencing were as follows: 5'-AAC AAG CGT GGC TTC AGC ATG-3' SEQ ID NO:5 (251S, numbering is based on the nucleotides from the 5' end of EST176696, and S indicates the sense direction), 5'-AGC AAT ATT GTT GGT CAT-3' SEQ ID NO:6 (336S), 5'-GAC TTG ACA GAA AAT CTA TAA GGG-3' SEQ ID NO:7 (393S), 5'-TTG TAC CAG ATG GAT TTC AA-3' SEQ ID NO:8 (673A, A indicates the antisense direction), 5'-CAG GTC TGA AAC AGA AAA CCT-3' SEQ ID NO:9 (829S), 5'-ATG AAT TCT CAT TAA TTA TTC AAT AAA-3' SEQ ID NO:10 (1455A). The coding sequence in EST176696 showed homology to a 250 amino acid stretch corresponding to the N-terminal 44% of human gp91phox, and contained a stop codon corresponding to the location in human gp91phox. 5' Rapid amplification of cDNA ends (RACE) was carried out using a human colon cDNA library and Marathon cDNA Amplification Kit (ClonTech) using 5'-ATC TCA AAA GAC TCT GCA CA-3' SEQ ID NO:11 (41A) as an internal gene-specific primer (Frohman et al. (1988) *Proc. Natl. Acad. Sci. USA* 85, 8998-9002). 5' RACE resulted in a 1.1 kb fragment representing the complete 5' sequence, based on homology with gp91phox.

Reamplification was performed with primers spanning the putative start and stop codons, using the 1.1 kb 5' RACE product and pSK-EST176696 for primer design. The amplified 1.7kb fragment was TA cloned into the PCR2.1 vector (Invitrogen, Carlsbad, CA). This recombinant vector is referred to as PCR-*mox*.

Figure 1(a-d) presents a comparison of the present amino acid sequences of human, bovine and murine gp91 phox with the human and rat mox1 proteins of the present invention and the human duox2 protein of the present invention. Also shown are the amino acid sequences for related plant enzyme proteins.

The encoded hp65mox ("mox" referring to mitogenic oxidase and "65" referring to its predicted molecular weight) is listed as SEQ ID NO:2. h-gp91phox (SEQ ID NO:12) and SEQ ID NO:2 differ in length by 3 residues and are 70% identical in their amino acid sequence. h-gp91phox and SEQ ID NO:2 show a greater percentage identity in the C-terminal half of the molecule which contains the putative NADPH and FAD binding sites, and there are several relatively long stretches of complete identity within this region.

A dendrogram (Figure 2) comparing the amino acid sequences of mouse and human gp91phox with that of mox1 SEQ ID NO:2 shows that the latter probably represents a distinct isoform of gp91phox. Two plant homologs of cytochrome b₅₅₈ large subunit are also indicated and represent more distant relatives of the human sequences. Human (and rat mox1 described more fully below) lack asparagine-linked glycosylation sites, which are seen in the highly glycosylated human and mouse gp91phox. Additionally, the hydropathy profiles of human gp91phox and mox1 are nearly identical and include five very hydrophobic stretches in the amino-terminal half of the molecules which are predicted to be membrane-spanning regions.

EXAMPLE 2

Expression of Mox1

Human multiple tissue northern (MTN) Blot I and Human MTN Blot IV (ClonTech) membranes were hybridized with the putative coding region of the PCR-mox vector at 68°C for several hours. The mox coding region was labeled by random priming with [α -³²P]dCTP (10 μ Ci) using the Prime-It II kit (Stratagene). For analysis of mox1 expression in cell lines, total RNA was prepared from 10⁶ cells using the High Pure RNA Isolation Kit (Boehringer Mannheim) or RNeasy kit (Quiagen). Total RNA (10-20 μ g) was separated on a 1% agarose formaldehyde mini-gel and transferred to a Nytran filter (Biorad) and immobilized by ultraviolet cross-linking.

Northern blotting revealed that the major location of mRNA coding for the mox1 protein was colon. The message was also detected in prostate and uterus. The human colon-carcinoma cell line, Caco-2, also expressed large quantities of mox1 message. Northern blotting of mRNA from rat aortic smooth muscle cells also showed strong hybridization, which increased roughly two-fold within 12 hours after treatment with platelet-derived growth factor. This increase in the expression of rat mox1 is consistent with the idea that mox1 contributes to the growth-stimulatory effects of PDGF.

EXAMPLE 3

Transfection of NIH3T3 Cells with SEQ ID NO:1

The nucleotide sequence (SEQ ID NO:1) encoding for production of the mox1 protein (SEQ ID NO:2) was subcloned into the *Not*I site of the pEF-PAC vector (obtained from Mary Dinauer, Indiana University Medical School, Indianapolis, IN) which has a puromycin resistance gene. Transfection was carried out as described in Sambrook et al., Molecular Cloning, A Laboratory Manual, Volumes 1-3, 2nd edition, Cold Spring Harbor Laboratory Press, N.Y., 1989. The SEQ ID NO:1 in pEF-PAC and the empty vector were separately transfected into NIH 3T3 cells using Fugene 6

(Boeringer Mannheim). About 2×10^6 cells maintained in DMEM containing 10% calf serum were transfected with 10 μ g of DNA. After 2 days, cells were split and selected in the same medium containing 1mg/ml puromycin. Colonies that survived in selection media for 10 to 14 days were subcultured continuously in the presence of puromycin.

Transfected cells exhibited a "transformed"-like morphology, similar to that seen with (V12)Ras-transfected cells, characterized by long spindle-like cells. The parent NIH 3T3 cells or cells transfected with the empty vector showed a normal fibroblast-like morphology.

EXAMPLE 4

Expression of *Mox1* (SEQ ID NO:1) in Transfected NIH3T3 Cells

To verify the expression of *mox1* mRNA after transfection, RT-PCR and Northern blotting were performed. Total RNAs were prepared from 10^6 cells using the High Pure RNA Isolation Kit (Boeringer Mannheim) or RNeasy kit (Qiagen). cDNAs for each colony were prepared from 1-2 μ g of total RNA using Advantage RT-PCR Kit (ClonTech). PCR amplification was performed using primers, 5'-TTG GCT AAA TCC CAT CCA-3' SEQ ID NO:13 (NN459S, numbering containing NN indicates numbering from the start codon of *mox1*) and 5'-TGC ATG ACC AAC AAT ATT GCT G-3' SEQ ID NO:14 (NN1435A). For Northern blotting, 10-20 μ g of total RNA was separated on a 1% agarose formaldehyde gel and transferred to a nylon filter. After ultraviolet (UV) cross-linking, filters were used for Northern blotting assay as described in Example 2.

Colonies expressing large amounts of *mox1* mRNA were chosen for further analysis. The expression of mRNA for glyceraldehyde 3 phosphate dehydrogenase in the various cell lines was normal.

EXAMPLE 5

Colony Formation on Soft Agar

5 10^5 to 10^3 cells stably transfected with human
mox1 gene SEQ ID NO:1 and with empty vector were prepared
in 0.3% warm (40°C) agar solution containing DMEM and 10%
calf serum. Cells were distributed onto a hardened 0.6% agar
plate prepared with DMEM and 10% calf serum. After three
weeks in culture (37°C, 5% CO₂) colony formation was
observed by microscopy.

10 Cells which were stably transfected with the empty
vector and cultured in soft agar for 3 weeks as above did not
display anchorage independent growth. In contrast, NIH 3T3
cells which had been stably transfected with the mox1 (SEQ ID
NO:1) and cultured for 3 weeks in soft agar demonstrated
anchorage independent growth of colonies.

15

EXAMPLE 6

NADPH-Dependent Superoxide Generation Assay

20 In one embodiment of the present invention, NIH
3T3 cells stably transfected with the human mox1 gene (SEQ ID
NO:1) were analyzed for superoxide generation using the
lucigenin (Bis-N-methylacridinium luminescence assay (Sigma,
St. Louis, MO, Li et al. (1998) *J. Biol. Chem.* 273, 2015-
2023). Cells were washed with cold HANKS' solution and
homogenized on ice in HANKS' buffer containing 15% sucrose
25 using a Dounce homogenizer. Cell lysates were frozen
immediately in a dry ice/ethanol bath. For the assay, 30 µg of
cell lysate was mixed with 200 µM NADPH and 500 µM
lucigenin. Luminescence was monitored using a LumiCounter
(Packard) at three successive one minute intervals and the
30 highest value was used for comparison. Protein concentration
was determined by the Bradford method.

35 Superoxide generation was monitored in lysates
from some of the stably transfected cell lines and was compared
with superoxide generation by the untransfected NIH 3T3 cell
lysates. The results are shown in Table 4. Cell lines 26, 27,
and 28 gave the highest degree of morphological changes by

microscopic examination corresponding to the highest degree of superoxide generation. The luminescent signal was inhibited by superoxide dismutase and the general flavoprotein inhibitor diphenylene iodonium, but was unaffected by added recombinant human p47phox, p67phox and Rac1(GTP- γ S), which are essential cytosolic factors for the phagocyte respiratory-burst oxidase.

Table 4

| 10 | <u>Cell Line Name</u> | <u>Superoxide Generation</u> |
|----|-------------------------|------------------------------|
| | | (RLU) |
| | Control (untransfected) | 6045 |
| | mox1-26 | 17027 |
| | mox1-27 | 14670 |
| 15 | mox1-28 | 18411 |
| | mox1-65 | 5431 |
| | mox1-615 | 11331 |
| | mox1-+3 | 8645 |
| | mox1-+10 | 5425 |
| 20 | mox1-pcc16 | 8050 |

In an alternate and preferred embodiment of the present invention, cells that had been stably transfected with mox1 (YA28) or with empty vector (NEF2) were grown in 10 cm tissue culture plates in medium containing DMEM, 10% calf serum, 100 units/ml penicillin, 100 μ g/ml streptomycin, and 1 μ g/ml puromycin to approximately 80% confluency. Cells (five tissue culture plates of each cell type) were washed briefly with 5 ml phosphate buffered saline (PBS) then dissociated from the plates with PBS containing 5 mM EDTA. Cells were pelleted by centrifuging briefly at 1000 x g.

To permeabilize the cells, freeze thaw lysis was carried out and this was followed by passage of the cell material through a small bore needle. The supernatant was removed and the cells were frozen on dry ice for 15 minutes. After cells were thawed, 200 μ l lysis buffer (HANKS' Buffered Salt

5 Solution - HBBS) containing a mixture of protease inhibitors from Sigma (Catalog # P2714) was added. Cells on ice were passed through an 18 gauge needle 10 times and 200 μ l of HBSS buffer containing 34% sucrose was added to yield a final concentration of 17% sucrose. Sucrose appeared to enhance stability upon storage. The combination of freeze-thawing and passage through a needle results in lysis of essentially all of the cells, and this material is referred to as the "cell lysate."

10 The cell lysates were assayed for protein concentration using the BioRad protein assay system. Cell lysates were assayed for NADPH-dependent chemiluminescence by combining HBSS buffer, arachidonic acid, and 0.01 - 1 μ g protein in assay plates (96 well plastic plates). The reaction was initiated by adding 1.5 mM NADPH and 75 μ M lucigenin to the
15 assay mix to give a final concentration of 200 μ M NADPH and 10 μ M lucigenin, and the chemiluminescence was monitored immediately. The final assay volume as 150 μ l. The optimal arachidonic acid concentration was between 50-100 μ M. A Packard Lumicount luminometer was used to measure
20 chemiluminescence of the reaction between lucigenin and superoxide at 37°C. The plate was monitored continuously for 60 minutes and the maximal relative luminescence unit (RLU) value for each sample was used for the graph.

25 Figure 3 shows the RLU at various concentrations of cell lysates from mox1-transfected (YA28) and vector control (NEF2) cells. The presence of NaCl or KCl within a concentration range of 50-150 μ M is important for optimal activity. $MgCl_2$ (1-5 mM) further enhanced activity by about 2-fold. This cell-free assay for mox1 NADPH-oxidase activity is
30 useful for screening modulators (inhibitors or stimulators) of the mox1 enzyme. The assay may also be used to detect mox and duox NADPH-oxidase activity in general and to screen for modulators (inhibitors or stimulators) of the mox and duox family of enzymes.
35

EXAMPLE 7

Nitro Blue Tetrazolium Reduction by Superoxide Generated by NIH 3T3 cells Transfected with the Mox1 cDNA (SEQ ID NO:1)

5 Superoxide generation by intact cells was monitored by using superoxide dismutase-sensitive reduction of nitroblue tetrazolium. NEF2 (vector alone control), YA26 (mox1 (SEQ ID NO:1)-transfected) and YA28 (mox1 (SEQ ID NO:1)-transfected) cells were plated in six well plates at 10 500,000 cells per well. About 24 hours later, medium was removed from cells and the cells were washed once with 1 mL Hanks solution (Sigma, St. Louis, MO). About 1 mL of filtered 0.25% Nitro blue tetrazolium (NBT, Sigma) was added in Hanks without or with 600 units of superoxide dismutase 15 (Sigma) and cells were incubated at 37°C in the presence of 5% CO₂. After 8 minutes the cells were scraped and pelleted at more than 10,000g. The pellet was re-suspended in 1 mL of pyridine (Sigma) and heated for 10 minutes at 100°C to solubilize the reduced NBT. The concentration of reduced NBT 20 was determined by measuring the absorbance at 510 nm, using an extinction coefficient of 11,000 M⁻¹cm⁻¹. Some wells were untreated and used to determine cell number.

25 The data are presented in Table 5 and Figure 4 and indicate that the mox1 (SEQ ID NO:1)-transfected cells generated significant quantities of superoxide.

Table 5

| | <u>NBT Reduction (nmols/10⁶ cells)</u> | <u>- SOD</u> | <u>+ SOD</u> |
|----|---|--------------|--------------|
| 30 | vector control cells | 2.5 ± 0.5 | 2.1 ± 0.5 |
| | YA26 (mox1) cells | 6.4 ± 0.2 | 3.4 ± 0.1 |
| | YA28 (mox1) cells | 5.2 ± 0.6 | 3.4 ± 0.3 |

35 -SOD, and +SOD mean in the absence or presence of added superoxide dismutase, respectively.

Because superoxide dismutase is not likely to penetrate cells, superoxide must be generated extracellularly. The amount of

superoxide generated by these cells is about 5-10% of that generated by activated human neutrophils.

EXAMPLE 8

5 *Modification of Intracellular Components in Mox1 Transfected Cells*

To test whether superoxide generated by *mox1* can affect intracellular "targets," aconitase activity in control and *mox*-transfected cell lines was monitored as described in Suh et al. 10 (1999) *Nature* 401, 79-82. Aconitase contains a four-iron-sulphur cluster that is highly susceptible to modification by superoxide, resulting in a loss of activity, and has been used as a reporter of intra-cellular superoxide generation. Aconitase activity was determined as described in Gardner et al. (1995) 15 *J. Biol. Chem.* 270, 13399-13405. Aconitase activity was significantly diminished in all three *mox*-transfected cell lines designated YA26, YA28 and YA212 as compared to the transfected control (Figure 5). Approximately 50% of the aconitase in these cells is mitochondrial, based on differential 20 centrifugation, and the cytosolic and mitochondrial forms were both affected. Control cytosolic and mitochondrial enzymes that do not contain iron-sulfur centres were not affected. Superoxide generated in *mox1*-transfected cells is therefore capable of reacting with and modifying intracellular 25 components.

EXAMPLE 9

30 *Tumor Generation in Nude Mice Receiving Cells Transfected with the Human *mox1* cDNA (SEQ ID NO:1)*

About 2×10^6 NIH 3T3 cells (either *mox1*-transfected with SEQ ID NO:1 or cells transfected using empty vector) were injected subdermally into the lateral aspect of the neck of 4-5 week old nude mice. Three to six mice were injected for each of three *mox1*-transfected cell lines, and 3 35 mice were injected with the cells transfected with empty vector (control). After 2 to 3 weeks, mice were sacrificed. The tumors were fixed in 10% formalin and characterized by

histological analysis. Tumors averaged 1.5 x 1 x 1 cm in size and showed histology typical of sarcoma type tumors. In addition, tumors appeared to be highly vascularized with superficial capillaries. Eleven of twelve mice injected with
5 mox1 gene-transfected cells developed tumors, while none of the three control animals developed tumors.

In another study, 15 mice were injected with mox1-transfected NIH 3T3 cells. Of the 15 mice injected, 14 showed large tumors within 17 days of injection, and tumors showed
10 expression of mox1 mRNA. Histologically, the tumors resembled fibrosarcomas and were similar to ras-induced tumors. Thus, ras and mox1 were similarly potent in their ability to induce tumorigenicity of NIH 3T3 cells in athymic mice.

15 **EXAMPLE 10**

Demonstration of the Role of Mox1 in Non-Cancerous Growth

A role in normal growth was demonstrated in rat aortic vascular smooth-muscle cells by using antisense to rat
20 mox1. Transfection with the antisense DNA resulted in a decrease in both superoxide generation and serum-dependent growth. Mox1 is therefore implicated in normal growth in this cell type.

25 **EXAMPLE 11**

Expression of Human Mox1 Protein (SEQ ID NO:2) in a Baculovirus Expression System

SEQ ID NO:2 was also expressed in insect cells using recombinant baculovirus. To establish the p65mox1
30 expressing virus system, the mox1 gene (SEQ ID NO:1) was initially cloned into the pBacPAK8 vector (Clontech, Palo Alto, CA) and recombinant baculovirus was constructed using standard methods according to manufacturer's protocols. Briefly, PCR amplified mox1 DNA was cloned into the KpnI
35 and EcoRI site of the vector. Primers used for PCR amplification were: 5'-CAA GGT ACC TCT TGA CCA TGG

GAA ACT-3' , SEQ ID NO:15, and 5'-ACG AAT TCA AGT
AAA TTA CTG AAG ATA C-3' , SEQ ID NO:16. Sf9 insect
cells (2×10^6 cells) were infected with 0.5 mg of linearized
baculovirus DNA sold under the trademark BACULOGOLD®
5 (PharMingen, San Diego, CA) and 5 mg pBacPAC8-p65mox1
using Transfection Buffers A and B (PharMingen, San Diego,
CA). After 5 days, the supernatants containing recombinant
viruses were harvested and amplified by infecting fresh sf9 cells
for 7 days. Amplification was carried out three times and the
10 presence of the recombinant virus containing mox1 DNA was
confirmed by PCR using the same primers. After three times
amplification of viruses, plaque purification was carried out to
obtain the high titer viruses. Approximately 2×10^8 sf9 cells in
agar plates were infected for 5 days with serial dilutions of
15 virus and were dyed with neutral red for easy detection of virus
plaques. Selected virus plaques were extracted and the presence
of the human mox1 DNA was confirmed again by PCR.

EXAMPLE 12

20 *Cloning of a Rat Homolog of p65mox (SEQ ID NO:2)*

cDNA clones of p65mox from a rat aortic smooth
muscle cell have been obtained. RT-PCR (reverse transcription
polymerase chain reaction) was carried out as follows: first
strand cDNA synthesis was performed using total RNA from rat
25 aortic vascular smooth muscle cells, oligo dT primer and
superscript II reverse transcriptase, and followed by incubation
with RNase H. Degenerate PCR primers were designed to
anneal to conserved areas in the coding regions of h-mox1 and
gp91phox of human (X04011), mouse (U43384) and porcine
30 (SSU02476) origin. Primers were: sense 5'-
CCIGTITGTCGIAATCTGCTSTCCTT-3', SEQ ID NO:17 and
antisense 5'-TCCCIGCAIAICCAAGTAGAARTAGATCTT-3',
SEQ ID NO:18. A major PCR product of the expected 1.1 kb
size was purified by agarose electrophoresis and used as
35 template in a second PCR amplification reaction.

An aliquot of the RT-PCR product was blunt-

ended, ligated into a modified Litmus 29 vector and used to transform XL10 competent *E. coli*. Approximately 120 bacterial colonies were screened for the presence of a full-length insert by direct PCR using vector primers and Taq polymerase. Plasmids were purified from 25 positive colonies and mapped by digestion with *Bam* HI. Representative plasmids from each digestion pattern were partially sequenced. Five out of 25 clones contained non-specific amplification products and 20 contained identical inserts similar to human (h)-mox1. One of the latter clones was fully sequenced and found to be 83% identical to h-mox1 over 1060 nucleotides. A 1.1 kb probe was generated by PCR amplification of the insert of a rat mox1 clone with the degenerate primers described above and used to hybridize to a Northern blot of rat vascular smooth muscle cell RNA. A single band, migrating between 28S rRNA and 18S rRNA, indicated the presence of a message with a size compatible to that of human mox-1 (2.6 kb).

To obtain full-length rat mox1, 3' and 5' rapid amplification of cDNA ends (RACE) reactions were performed as describe above, using the gene-specific primers 5'-TTGGCACAGTCAGTGAGGATGTCTTC-3', SEQ ID NO:19 and 5'-CTGTTGGCTTCTACTGTAGCGTTCAAAGTT-3', SEQ ID NO:20 for 3' and 5' RACE, respectively. Single major 1.5 kb and 850 bp products were obtained for 3' and 5' RACE, respectively. These products were purified by agarose gel eletrophoresis and reamplified with Taq polymerase. Both products were cloned into the pCR 2.1 vector and used to transform electrocompetent XL1 blue *E. coli*. The RACE products were sequenced and new terminal primers were designed:

sense 5'-TTCTGAGTAGGTGTGCATTTGAGTGTCAATAAGAC-3' (SEQ ID NO:43), and antisense 5'-TTTTCCGTCAAATTATAACTTTTTATTTTCTTTTATAACACAT-3' (SEQ ID NO:44). PCR amplification of rat VSMC cDNA was performed using these primers.

A single 2.6 kb product was obtained, ligated into pCR 2.1 and used to transform electrocompetent XL1 blue *E. coli*. The insert was sequenced with 12 sense and 14 antisense primers. Its length is 2577 bp (including primer sequences), comprising a 1692 bp open reading frame, 127 bp 5' and 758 bp 3' untranslated regions. The presence of six in-frame stop codons in the 5' untranslated region suggests that the full length coding region has been obtained. Consensus polyadenylation sequences are present at nucleotides 2201 and 2550. Conceptual translation yields a 563 amino acid peptide, one residue shorter than the human deduced sequence. This new amino acid sequence is more similar to human mox1 SEQ ID NO:3 (82% identity) than to mouse gp91phox SEQ ID NO:38 (55% identity), suggesting that it is indeed rat mox1 (SEQ ID NO:21). This rat (r) homolog of p65mox protein is called r-p65mox or p65mox/rat.pep and is shown as SEQ ID NO:21. The nucleotide sequence encoding for r-p65mox is shown as SEQ ID NO:22.

20

EXAMPLE 13

Expression of rat (r)-p65mox mRNA in Vascular Smooth Muscle and Induction by Angiotensin II, Platelet-Derived Growth Factor (PDGF), and Phorbol Myristic Acid (PMA)

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30

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Using the partial cDNA clone from rat, we have examined cultured rat aortic smooth muscle cells for expression of message for r-p65mox. We have observed the mRNA for r-p65mox in these cells. It has been previously reported (Griendling et al. (1994) *Circ. Res.* 74, 1141-1148; Fukui et al. (1997) *Circ. Res.* 80, 45-51; Ushio-Fukai et al. (1996) *J. Biol. Chem.* 271, 23317-23321) that *in vitro* or *in vivo* treatment with angiotensin II (AII) is a growth stimulus for vascular smooth muscle cells, and that AII induces increased superoxide generation in these cells. Platelet-derived growth factor (PDGF) and PMA are proliferative signals for vascular smooth muscle cells. We observed that the mRNA for r-p65mox was induced approximately 2-3 fold by angiotensin II (100 nM),

corresponding to the increased level of superoxide generation. Thus, the increased superoxide generation in these cells correlates with increased expression of the mRNA for this enzyme. The mRNA for r-p65mox also increased 2 or more fold in response to the growth stimulus PDGF (20 ng/ml), and 2-3 fold in response to PMA. Quantitation by densitometry revealed that rat mox1 message was induced nearly 4-fold at the 6 and 12 hour time points in response to PDGF, and about 2-fold at the 12 hour time point in response to AII. 28S RNA was used as a control for RNA recovery.

EXAMPLE 14

Antibodies to Fragments of Human (h)-p65mox (SEQ ID NO:2)

Polyclonal antibodies were raised in rabbits against the C-terminal half of h-p65mox (residues 233 through 564, SEQ ID NO:23) which is predicted to fold into a cytosolic domain containing FAD and the NADPH or NADH binding site. This domain was expressed in *E. coli* as an N-terminal GST-fusion protein and was purified on glutathione agarose by standard methods. Two anti-peptide antibodies were also made against h-p65mox (residues 243-256, referred to as Peptide A, SEQ ID NO:24) and h-65mox (residues 538-551, referred to as Peptide B, SEQ ID NO:25). Peptides were conjugated to keyhole limpet hemocyanin (KLH) using glutaraldehyde.

Antigens were injected into different rabbits initially in complete Freund's adjuvant, and were boosted 4 times with antigen in incomplete Freund's adjuvant at intervals of every three weeks. Approximately 0.5 mg to 1 mg of peptide was administered at each injection. Blood was drawn 1 week after each boost and a terminal bleed was carried out 2 weeks after the final boost. Antibodies to Peptide A and Peptide B were affinity purified by column chromatography through peptide A or peptide B conjugated to Affigel 15 (Bio-Rad, Richmond, CA). 10 mg of peptide was covalently crosslinked to 2 ml of Affigel 15 resin and the gel was washed with 20 ml of binding buffer (20 mM Hepes/NaOH, pH 7.0, 200 mM NaCl,

and 0.5 % Triton X-100). The remaining functional N-hydrosuccinimide was blocked with 100 μ l of 1 M ethanolamine. After washing with 20 ml of binding buffer, 5 ml of the antiserum was incubated with the pep A-conjugated Affigel 15 resin overnight at 4°C. Unbound protein was washed away with 20 ml of binding buffer. Elution of the antibodies from the gel was performed with 6 ml of elution buffer (100 mM glycine/HCl, pH 2.5, 200 mM NaCl, and 0.5% Triton X-100). The eluate was then neutralized by adding 0.9 ml of 1 M Tris/HCl, pH 8.0. The GST-fusion form of truncated p65mox1 protein (residues 233-566, SEQ ID NO:23) was expressed in *E. coli*. Samples (20 μ g each) were run on 12 % SDS-PAGE either before or 1 or 4 hours after induction with 100 μ M IPTG (isopropyl β -thiogalactoside).

The extracted proteins were subjected to immunoprobings with affinity purified antiserum to peptide A at a 1:1000 dilution. The detection of antigens was performed using an enhanced chemiluminescence kit (Amersham, Buckinghamshire, UK). The affinity purified antibody to mox1 (243-256, SEQ ID NO:24) was used at a dilution of 1:1000 in a Western blot in which a total of 10 μ g of protein was added to each lane. The major band observed at 4 hours after IPTG induction corresponded to the size of the GST-mox1 expressed in bacteria containing the pGEX-2T vector encoding the GST-mox1 fusion protein.

Example 15

Presence of an NAD(P)H Oxidase in Ras-Transformed Fibroblasts

A superoxide-generating NADPH oxidase activity was detected in homogenates from NIH 3T3 cells, and this activity increased about 10-15 fold in Ras-transformed NIH 3T3 cells (Table 6). To establish the stable Ras-transformed cell lines, the DNA for human Ras encoding an activating mutation at amino acid number 12 (Valine, referred to as V12-Ras) was subcloned into BamH1 and EcoR1 sites of pCDNA3 vector

which has a neomycin resistance gene. V12-Ras in pCDNA3 and empty vector were transfected into NIH 3T3 cells using Lipofectamine Plus (Gibco). 2×10^6 cells were maintained with DMEM containing 10% calf serum and transfected with 1 mg of DNA. After 2-days, cells were split and selected with the same medium but containing 1 mg/ml neomycin. Colonies surviving in selection media for 10 to 14 days were sub-cultured and characterized by immunoblot analysis using antibody against human H-Ras.

The expression of Ras in cells transfected with pcDNA-3 vector alone or in three cell lines transfected with V12-Ras in the same vector was analyzed on a Western blot. The three cell lines were named V12-Ras-7, V12-Ras-4, and V12-Ras-8. The expression of V12-Ras varied widely among the three cell lines tested. The V12-Ras-4 cell line expressed the highest level of Ras followed by the V12-Ras-8 cell line. The V12-Ras-7 cell line expressed the lowest level of Ras.

Lysates from each of these lines were then prepared and tested for their ability to generate superoxide. For each cell line, cells were washed with cold HANKS' balanced salt solution (HBSS), collected by centrifugation, kept on dry-ice for more than 30 min, and disrupted by suspending in low salt buffer (LSB; 50 mM Tris/HCl, pH 7.5, 1 mM PMSF, and protease cocktail from Sigma) and passing through a syringe needle (18 gauge) ten times. Cell lysates were frozen in dry-ice immediately after determining the protein concentration.

Table 6 shows superoxide generation in the transfected cells measured using the lucigenin luminescence assay. For the assay, 5 μ g of cell lysates were incubated with the reaction mixture containing 10 μ M lucigenin (luminescent probe) and 100 μ M NADPH (substrate) in the presence or absence of 100 μ M arachidonate in the absence or presence of 100 U of superoxide dismutase (SOD) or 1 μ M diphenyleneiodonium (DPI). Luminescence of the reaction mixture was monitored for 0.5 second by LumiCounter (Packard) for four times at 3 second intervals. RLU in Table 5

refers to relative luminescence units.

As shown in Table 6, the luminescence was partially inhibited by superoxide dismutase indicating that the signal was due at least in part to the generation of superoxide. DPI, a known inhibitor of both neutrophil and non-neutrophil NADPH oxidase activities, completely inhibited activity. The generation of superoxide correlated with the expression of Ras in the three cell lines. Thus, oncogenic Ras appears to induce an NADPH-dependent superoxide generating activity that is similar to the activity catalyzed by p65mox1.

Table 6

| | | RLU/5 μ g protein | | |
|----|--------------------|-----------------------|----------|----------|
| | | no additions | plus SOD | plus DPI |
| 15 | Vector Control (1) | 465 | 154 | 48 |
| | V12-Ras-7 (2) | 1680 | 578 | 39 |
| | V12-Ras-4 (3) | 5975 | 2128 | 36 |
| | V12-Ras-8 (4) | 4883 | 2000 | 35 |

EXAMPLE 16

Molecular Cloning of Another Rat mox1 cDNA Called Rat mox1B

A rat cDNA library was screened in an effort to identify new rat mox sequences. The library was constructed in a ZAP express lambda phage vector (Stratagene, La Jolla, CA) using RNA isolated from rat vascular smooth muscle cells which had been exposed to 100 nM angiotensin II for 4 hours. The library was screened using standard blot hybridization techniques with the rat mox1 probe described previously. Fifteen individual clones were obtained that were characterized by PCR and restriction mapping. Two different types of clones were thus identified and representatives of each type were sequenced. A clone of the first type (representative of 13) was found to be similar to the previously identified rat mox1 and

was thus named rat mox1B. Clones of the second type (representative of 2) were incomplete rat mox sequences.

5 The length of the rat mox1B nucleotide sequence is 2619 bp and is listed as SEQ ID NO:41. The single longest 1497 bp open reading frame encompasses nucleotides 362 to 1858. The presence of two in-frame stop codons in the 5' untranslated region at nucleotides 74 and 257 indicates that the full-length coding region has been isolated. Two putative polyadenylation sites are present at positions 2243 and 2592.
10 Alignment of the rat mox1 nucleotide sequence (SEQ ID NO:22) and the rat mox1B nucleotide sequence (SEQ ID NO:41) shows that the two nucleotides sequences are identical except at their 5' ends, suggesting that they may represent two alternatively spliced messages from the same gene. Sequence
15 identity starts at nucleotides 269 and 311, for rat mox1 and rat mox1B, respectively.

Conceptual translation of the rat mox1B nucleotide sequence (SEQ ID NO:41) yields a 499 amino acid sequence with a predicted molecular weight of 58 kDa. This amino acid
20 sequence for rat mox1B protein is shown in SEQ ID NO:42. Alignment of the deduced amino acid sequences for rat mox1 (SEQ ID NO:21) and rat mox1B (SEQ ID NO:42) indicates that rat mox1B is identical to rat mox1A, except for a missing stretch of 64 residues at the N-terminus. Therefore, rat mox1B
25 appears to be a splicing variant derived from the same gene as rat mox1.

EXAMPLE 17

30 *Sequence Analysis and Cloning of the Human Mox2 cDNA (SEQ ID NO:3) Encoding for Production of the Human Mox2 Protein (SEQ ID NO:4)*

Note that the mox2 protein as described herein, was described in U.S. Provisional Application Serial No. 60/149,332 as mox3.

35 A blast search was carried out using the sequence of mox1 as a query sequence. The sequence identified by this

search was a sequence present in the GenBank database that contains regions of homology with *mox1* and *gp91phox*. The GenBank sequence located in the search was a 90.6 kb sequenced region of human chromosome 6 (6q25.1-26) that was reported as a GenBank direct submission dated February 9, 1999 and given the Accession No. AL031773. Sequencing was carried out as part of the human genome sequencing project by S. Palmer, at Sanger Centre, in Hinxton, Cambridgeshire, UK. The GenBank sequence was reported as being similar to "Cytochrome B" and was not reported as having any homology or relation to a *mox* protein. The sequence contained a theoretical amino acid sequence that was derived by computer using an algorithm that predicted intron/exon boundaries and coding regions. This predicted region contained a 545 amino acid sequence that was 56% identical to *mox1* and 58% identical to *gp91phox*.

In the present invention, based on the GenBank genomic sequence and the homologies described above, several specific primers were designed and used to determine the tissue expression patterns of a novel *mox* protein, *mox2*, using Human Multiple Tissue PCR Panels (Clontech, Palo Alto, CA). The primers were as follows: Primer 1: 5'-CCTGACAGATGTATTTCACTACCCAG-3' (SEQ ID NO:49); Primer 2: 5'-GGATCGGAGTCACTCCCTTCGCTG-3' (SEQ ID NO:50); Primer 3: 5'-CTAGAAGCTCTCCTTGTTGTAATAGA-3' (SEQ ID NO:51); Primer 4: 5'-ATGAACACCTCTGGGGTCAGCTGA-3' (SEQ ID NO:52). It was determined that *mox2* is expressed primarily in fetal tissues, with highest expression in fetal kidney, with expression also seen in fetal liver, fetal lung, fetal brain, fetal spleen and fetal thymus. Among 16 adult tissues tested, *mox2* expression was seen in brain, kidney, colon and lung, although levels of expression appeared to be very low.

Additionally, the 5' RACE (RACE = Rapid Amplification of cDNA Ends) and 3' RACE techniques were used to complete the sequence of the 5' and 3' regions of *mox2*.

(5' RACE kit and 3' RACE kit were from Clontech, Palo Alto, CA and are more fully described in Frohman et al. (1988) *Proc. Natl. Acad. Sci. USA* 85, 8998-9002. The 5' RACE and 3'-RACE techniques were carried out using a human fetal kidney library (Marathon-Ready cDNA library, Cat. #7423-1), using the following specific primers: 5'-RACE: Primer 4: 5'-ATGAACACCTCTGGGGTCAGCTGA-3' (SEQ ID NO:53); Primer 5: 5'-GTCCTCTGCAGCATTGTTCTCTTA-3' (SEQ ID NO:54); 3'-RACE: Primer 1: 5'-CCTGACAGATGTATTTCACTACCCAG-3' (SEQ ID NO:55); Primer 2: 5'-GGATCGGAGTCACTCCCTTCGCTG-3' (SEQ ID NO:56). The RACE procedures were successful in completing the 5' sequence and in confirming the 3' sequence. The complete coding sequence of *mox2* is shown in SEQ ID NO:2, while the predicted amino acid sequence of *mox2* is shown in SEQ ID NO:4.

In comparing the sequences of the present invention to the predicted coding regions of the GenBank sequence, the GenBank sequence did not contain a start codon, appeared to be missing approximately 45 base pairs at the N-terminus, and contained one other major difference in the predicted coding region which could have been due to inaccurate computer prediction of intron/exon boundaries.

25

EXAMPLE 18

Sequence Analysis and Partial Cloning of the Human Duox2 cDNA (SEQ ID NO:47) Encoding for Production of the Human Duox2 Protein (SEQ ID NO:48)

A partial cDNA clone of *duox2* was obtained as follows. A 535-base portion of an expressed sequence tag (EST *zc92h03.rl*; Genbank accession no. W52750) from human pancreatic islet was identified using the human *gp91phox* amino-acid sequence as a query in a Blast search. The bacterial strain #595758 containing the EST sequence *zc92h03.rl* in the pBluescript SK-vector was purchased from ATCC (Rockville, MD). The DNA inserted into the pBluescript SK-vector was

further sequenced using T7 and T3 vector promoters as well as sequence specific internal primers. The EST encoded 440 amino acids showing a 24.4% identity to gp91phox, including a stop codon corresponding to the C-terminus of gp91phox. 5'-RACE was carried out using mRNA obtained from human colon carcinoma cells (CaCo2) and the Marathon cDNA Amplification Kit (ClonTech, Palo Alto). The following gene-specific primers were used for this procedure: 5'-GAAGTGGTGGGAGGCGAAGACATA-3' (SEQ ID NO:26) and 5'-CCTGTCATACCTGGGACGGTCTGG-3' (SEQ ID NO:27).

The results of the 5'-RACE yielded an additional 2 kilobase of sequenced DNA but this region did not contain the start codon. To complete the sequence of the 5' and 3' regions of duox2, 5'-RACE and 3'-RACE were carried out using a human adult pancreas mRNA (Clontech, Palo Alto, CA) with the kit of 5' RACE System for Rapid Amplification of cDNA Ends version 2.0 (Gibco BRL, Gaithersburg, MD). PCR done using the following specific primers resulted in a total predicted amino acid sequence of about 1000 residues: 5'-RACE: Primer 3: 5'-GAGCACAGTGAGATGCCTGTTCAG-3' (SEQ ID NO:28); Primer 4: 5'-GGAAGGCAGCAGAGAGCAATGATG-3' (SEQ ID NO:29) (for nested PCR); 3'-RACE Primer 5: 5'-ACATCTGCGAGCGGCACTTCCAGA-3' (SEQ ID NO:30) Primer 6: 5'-AGCTCGTCAACAGGCAGGACCGAGC-3' (SEQ ID NO:31) (for nested PCR).

EXAMPLE 19

Sequence Analysis and Cloning of the Human Duox1 cDNA (SEQ ID NO:45) Encoding for Production of the Human Duox1 Protein (SEQ ID NO:46)

A cDNA clone of duox1 was obtained as follows. A homologous 357-base portion of an expressed sequence tag (EST nr80d12.s1; Genbank accession no. AA641653) from an invasive human prostate was identified by using the partial

duox2 predicted amino-acid sequence described above as a query in a Blast search. The bacterial strain #1441736 containing the EST sequence nr80d12.s1 in the pBluescript SK-vector was purchased from ATCC (Rockville, MD). The DNA inserted into the pBluescript SK-vector was further sequenced using T7 and T3 vector promoters as well as sequence specific internal primers. The EST insert encoded 673 amino acids with no start or stop codons present. Northern Blot analysis of duox1 indicated the gene was about 5.5 kilobase pairs. To complete the sequence of 5' and 3' regions of duox1, 5' RACE and 3'-RACE were carried out using a human adult lung mRNA (Clontech, Palo Alto, CA) with the kit of 5' RACE System for Rapid Amplification of cDNA Ends version 2.0 (Gibco BRL, Gaithersburg, MD). The RACE procedure was carried out using the following specific primers: 5'-RACE: Primer 5: 5'-GCAGTGCATCCACATCTTCAGCAC-3'(SEQ ID NO:32); Primer 6: 5'-GAGAGCTCTGGAGACACTTGAGTTC-3' (SEQ ID NO:33) (for nested PCR); 3'-RACE Primer 7: 5'-CATGTTCTCTCTGGCTGACAAG-3' (SEQ ID NO:34); Primer 8: 5'-CACAATAGCGAGCTCCGCTTCACGC-3' (SEQ ID NO:35) (for nested PCR). RACE procedures were successful in completing the 5' sequence and the 3' sequence of duox1. The open reading frame is approximately 4563 base pairs.

25

EXAMPLE 20

Tissue Expression of Duox1 and Duox2

Based on the duox1 sequence data, several specific primers were designed (Primer 1a: 5'-GCAGGACATCAACCCTGCACTCTC-3' (SEQ ID NO:36); Primer 2a: 5'-AATGACACTGTACTGGAGGCCACAG-3' (SEQ ID NO:57); Primer 3a: 5'-CTGCCATCTACCACACGGATCTGC-3' (SEQ ID NO:58); Primer 4a: 5'-CTTGCCATTCCAAAGCTTCCATGC-3' (SEQ ID NO:59) and used these to determine the tissue expression patterns of duox1 using Human Multiple Tissue PCR Panels

35

(Clontech, Palo Alto, CA). It was determined that duox1 is expressed primarily in lung, testis, placenta, prostate, pancreas, fetal heart, fetal kidney, fetal liver, fetal lung, fetal skeletal muscle and thymus, with highest expression in adult and fetal lung. Among 16 adult tissues and 8 fetal tissues tested, duox1 expression in brain, heart, kidney, colon, ovary, thymus, fetal brain and fetal spleen appeared to be low.

Two duox2 specific primers were also used to determine the tissue expression patterns of duox2 using Human Multiple Tissue PCR (polymerase chain reaction) Panels (Clontech, Palo Alto, CA). (Primer 1b: 5'-GTACAAGTCAGGACAGTGGGTGCG-3' (SEQ ID NO:60); Primer 2b: 5'-TGGATGATGTCAGCCAGCCACTCA-3' (SEQ ID NO:61)). Duox2 is expressed primarily in lung, pancreas, placenta, colon, prostate, testis and fetal tissues, with highest expression in adult lung and fetal tissues. Among 16 adult tissues and 8 fetal tissues tested, duox2 expression in brain, heart, kidney, liver, skeletal muscle, thymus and fetal brain appeared to be low.

EXAMPLE 21

Role of Duox1 and Duox2 in Collagen Crosslinking

To investigate a possible role for the human duox1 and duox2, the model organism *Caenorhabditis elegans* and a new reverse genetic tool, RNA interference (RNAi), were used to "knock out" the homologues of duox in this organism (Fire et al. (1998) *Nature* 391, 806-811). This technique involved injection of double stranded RNA encoding a segment of Ce-duox1 or Ce-duox2 into gonads of *C. elegans* N2 hermaphrodites. Injected worms were then allowed to lay eggs, and the harvested eggs were allowed to develop and the F1 progeny were scored for phenotypes. This procedure has been documented to "knock-out" the expression of the gene of interest (Fire et al. (1998) *Nature* 391, 806-811).

In the case of Ce-duox1 and Ce-duox2, the knockout animals resulted in a complex phenotype including

worms with large superficial blisters, short or "dumpy" worms, worms with locomotion disorders, and worms with retained eggs and/or larvae. Because of the high identity between Ce-duox1 and Ce-duox2, three different RNA constructs were predicted to knock out either both genes or Ce-duox2 alone. In all cases, essentially the same group of phenotypes was obtained. Most or all of these phenotypes had been described previously in *C. elegans* mutated in the collagen biosynthetic pathway. *C. elegans* has an extracellular structure known as the cuticle, a complex sheath composed largely of cross-linked collagen, which functions as the exoskeleton of the nematode. Cross-linking of collagen in nematodes occurs in part by cross-linking tyrosine residues, and peroxidases such as sea urchin ovoperoxidase and human myeloperoxidase have previously been shown to be capable of carrying out this reaction.

Based upon the similarities of the phenotypes obtained, the Ce-duox1/2 knockout worms were examined for the presence of dityrosine linkages, using an HPLC methodology (Andersen, S.O. (1966) *Acta Physiol. Scand.* 66, Suppl. 263-265; Abdelrahim et al. (1997) *J. Chromatogr. B Biomed. Sci. Appl.* 696, 175-182). It was determined that dityrosine linkages, while easily detected in the wild type worms, were almost completely lacking in the knockout worms. Thus, an inability to catalyze dityrosine cross-linking accounts for the phenotype of *C. elegans* failing to express Ce-duox1/2. These data support the concept that the duox enzymes in higher organisms can probably function in a similar manner to modulate the extracellular milieu, possibly the extracellular matrix and/or the basement membrane.

All patents, publications and abstracts cited above are incorporated herein by reference in their entirety. It should be understood that the foregoing relates only to preferred embodiments of the present invention and that numerous modifications or alterations may be made therein without

departing from the spirit and the scope of the present invention as defined in the following claims.

CLAIMS

- 5 1. A protein capable of stimulating superoxide production, wherein the protein comprises mox or duox, a fragment thereof or a conservative substitution thereof.
- 10 2. The protein of Claim 1, wherein the protein, the fragment thereof, or the conservative substitution thereof comprises the amino acid sequence of SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, or SEQ ID NO:48, a fragment thereof, or a conservative substitution thereof.
- 15 3. A nucleotide sequence encoding for the protein, the fragment thereof or the conservative substitution thereof as recited in Claim 1.
- 20 4. The nucleotide sequence of Claim 3, wherein the nucleotide sequence comprises SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, or SEQ ID NO:47, a fragment thereof, or a conservative substitution thereof.
- 25 5. A vector, wherein the vector comprises a nucleotide sequence encoding for the protein, the fragment thereof or the conservative substitution thereof, as recited in Claim 1.
- 30 6. The vector of Claim 5 wherein the nucleotide sequence comprises SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:22, SEQ ID NO:41, SEQ ID NO:45, or SEQ ID NO:47, a fragment thereof, or a conservative substitution thereof.
- 35 7. A cell containing the vector of Claim 5.
8. A cell containing the vector of Claim 6.

9. An antibody, wherein the antibody is capable of binding to the protein, the fragment thereof, or the conservative substitution thereof, as recited in Claim 1.
- 5 10. The antibody of Claim 9, wherein the protein, the fragment thereof, or the conservative substitution thereof, has the amino acid sequence of SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, or SEQ ID NO:48, a fragment thereof, or a conservative substitution thereof.
- 10 11. A method of stimulating superoxide formation comprising administration, in vitro or in vivo, of a composition comprising the protein, the fragment thereof, or the conservative substitution thereof of Claim 1 in a
- 15 pharmaceutically acceptable carrier.
12. The method of Claim 11, wherein the protein, the fragment thereof, or the conservative substitution thereof, comprises the amino acid sequence of SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, or SEQ ID NO:48, a fragment thereof, or a conservative substitution thereof.
- 20 13. A method of stimulating superoxide formation comprising administration, in vitro or in vivo, of a composition comprising the vector of Claim 5 in a pharmaceutically acceptable carrier.
- 25 14. A method of stimulating superoxide formation comprising administration, in vitro or in vivo, of a composition comprising the vector of Claim 6 in a pharmaceutically acceptable carrier.
- 30 15. A method for determining the activity of a drug comprising measuring the activity of the protein, the fragment thereof or the conservative substitution thereof, as recited in
- 35

Claim 1, to stimulate superoxide production following administration of the drug.

5 16. The method of Claim 15, wherein the protein, the fragment thereof or the conservative substitution thereof comprises the amino acid sequence of SEQ ID NO:2, SEQ ID NO:4, SEQ ID NO:21, SEQ ID NO:42, SEQ ID NO:46, or SEQ ID NO:48, a fragment thereof, or a conservative substitution thereof.

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FIGURE 1(a)

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| 155 | F | V | R | Q | R | I | K | N | P | E | G | G | L | Y | V | A | V | T | R | L | A | G | I | T | G | V | V | I | T | L | gp91phox.bovine | | | | |
| 155 | F | A | R | E | K | I | K | N | P | E | G | G | L | Y | V | A | V | T | R | L | A | G | I | T | G | I | V | I | T | L | gp91phox.mouse | | | | |
| 157 | P | I | Q | S | R | - | - | - | N | T | T | V | E | Y | V | T | F | T | S | V | A | G | L | T | G | V | I | M | T | I | Mox1.human | | | | |
| 156 | P | I | Q | S | P | - | - | - | N | V | T | V | M | Y | A | A | F | T | S | I | A | G | L | T | G | V | V | A | T | V | Mox1.rat | | | | |
| 156 | P | V | R | T | F | P | T | N | T | T | T | E | L | R | T | I | - | - | - | A | G | V | T | G | L | V | I | S | L | mox2.human | | | | | |
| 169 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | M | K | G | T | D | G | W | T | G | V | T | M | V | cytb558/arabidopsis.pep | | |
| 162 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | V | K | G | V | E | G | I | T | G | V | I | M | V | cytb558.rice.pep | | |
| 184 | C | L | I | L | I | I | T | S | S | T | K | T | I | R | R | S | Y | - | - | - | - | - | - | - | - | - | - | - | - | - | - | F | gp91phox.human | | |
| 185 | C | L | I | L | I | I | T | S | S | T | K | T | I | R | R | S | Y | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | F | gp91phox.bovine | |
| 185 | C | L | I | L | I | I | T | S | S | T | K | T | I | R | R | S | Y | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | F | gp91phox.mouse | |
| 184 | A | L | I | L | M | V | T | S | A | T | E | F | I | R | R | S | Y | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | F | Mox1.human | |
| 183 | A | L | V | L | M | V | T | S | A | M | E | F | I | R | R | N | Y | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | F | Mox1.rat | |
| 183 | A | L | V | L | I | M | T | S | S | T | E | F | I | R | Q | A | S | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | Y | mox2.human | |
| 183 | L | M | L | V | A | Y | V | L | A | Q | S | W | F | R | R | N | R | A | N | L | P | K | S | L | K | R | L | T | G | F | cytb558/arabidopsis.pep | | | | |
| 176 | C | M | I | I | A | F | T | L | A | T | R | W | F | R | R | S | L | V | K | L | P | R | P | F | D | K | L | T | G | F | cytb558.rice.pep | | | | |
| 202 | E | V | F | W | Y | T | H | H | L | F | V | I | F | F | I | G | L | A | I | H | G | A | E | R | I | V | R | G | Q | T | gp91phox.human | | | | |
| 203 | E | V | F | W | Y | T | H | H | L | F | V | I | F | F | I | G | L | A | I | H | G | A | Q | R | I | V | R | G | Q | T | gp91phox.bovine | | | | |
| 203 | E | V | F | W | Y | T | H | H | L | F | V | I | F | F | I | G | L | A | I | H | G | A | E | R | I | V | R | G | Q | T | gp91phox.mouse | | | | |
| 202 | E | V | F | W | Y | T | H | H | L | F | I | F | Y | I | L | G | L | I | H | G | I | G | G | I | V | R | G | Q | T | Mox1.human | | | | | |
| 201 | E | L | F | W | Y | T | H | H | L | F | I | I | Y | I | I | C | L | I | H | G | L | G | G | I | V | R | G | Q | T | Mox1.rat | | | | | |
| 201 | E | L | F | W | Y | T | H | H | L | F | I | I | V | F | F | L | S | L | A | I | H | G | T | G | R | I | V | R | G | O | T | mox2.human | | | |
| 213 | N | A | F | W | Y | S | H | H | L | F | V | I | V | Y | V | L | L | I | V | H | G | - | - | - | - | - | - | - | - | - | - | - | cytb558/arabidopsis.pep | | |
| 206 | N | A | F | W | Y | S | H | H | L | F | I | I | V | Y | I | A | L | I | V | H | G | - | - | - | - | - | - | - | - | - | - | - | cytb558.rice.pep | | |
| 232 | A | E | S | L | A | V | H | N | I | T | V | C | E | Q | K | I | S | E | W | G | K | I | K | - | E | C | P | I | P | Q | gp91phox.human | | | | |
| 233 | A | E | S | L | L | K | H | Q | P | R | N | C | Y | Q | N | I | S | Q | W | G | K | I | E | - | N | C | P | I | P | E | gp91phox.bovine | | | | |
| 233 | A | E | S | L | E | E | H | N | L | D | I | C | A | D | K | I | E | E | W | G | K | I | K | - | E | C | P | V | P | K | gp91phox.mouse | | | | |
| 232 | E | E | S | M | N | E | S | H | P | R | K | C | A | E | S | F | E | M | W | D | D | R | D | S | H | C | R | R | P | K | Mox1.human | | | | |
| 231 | E | E | S | M | S | E | S | H | P | R | N | C | S | Y | S | F | H | E | W | D | K | Y | E | R | S | C | R | S | P | H | Mox1.rat | | | | |
| 231 | Q | D | S | L | S | L | H | N | I | T | F | C | R | D | R | Y | A | E | W | Q | T | V | A | - | Q | C | P | V | P | O | mox2.human | | | | |
| 234 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | cytb558/arabidopsis.pep | | |
| 227 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | cytb558.rice.pep | | |
| 261 | F | A | G | N | P | P | M | T | W | K | W | I | V | G | P | M | F | L | Y | L | C | E | R | L | V | R | F | W | R | S | gp91phox.human | | | | |
| 262 | F | S | G | N | P | P | M | T | W | K | W | I | V | G | P | M | F | L | Y | L | C | E | R | L | V | R | F | W | R | S | gp91phox.bovine | | | | |
| 262 | F | A | G | N | P | P | M | T | W | K | W | I | V | G | P | M | F | L | Y | L | C | E | R | L | V | R | F | W | R | S | gp91phox.mouse | | | | |
| 262 | F | E | G | H | P | P | E | S | W | K | W | I | L | A | P | V | I | L | Y | I | C | E | R | I | L | R | F | Y | R | S | Mox1.human | | | | |
| 261 | F | V | G | Q | P | P | E | S | W | K | W | I | L | A | P | I | A | F | Y | I | F | E | R | I | L | R | F | Y | R | S | Mox1.rat | | | | |
| 260 | F | S | G | K | E | P | S | A | W | K | W | I | L | G | P | V | V | L | Y | A | C | E | R | I | I | R | F | W | R | F | mox2.human | | | | |
| 243 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | cytb558/arabidopsis.pep | | |
| 236 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | cytb558.rice.pep | | |
| 291 | Q | Q | K | V | V | - | - | - | I | T | K | V | V | T | H | P | F | K | T | I | E | L | Q | M | K | K | - | - | - | - | - | - | - | gp91phox.human | |
| 292 | Q | Q | K | V | V | - | - | - | I | T | K | V | V | T | H | P | F | K | T | I | E | L | Q | M | K | K | - | - | - | - | - | - | - | - | gp91phox.bovine |
| 292 | Q | Q | K | V | V | - | - | - | I | T | K | V | V | T | H | P | F | K | T | I | E | L | Q | M | K | K | - | - | - | - | - | - | - | - | gp91phox.mouse |
| 292 | Q | Q | K | V | V | - | - | - | I | T | K | V | V | M | H | P | S | K | V | L | E | L | Q | M | N | K | - | - | - | - | - | - | - | Mox1.human | |
| 291 | R | Q | K | V | V | - | - | - | I | T | K | V | V | M | H | P | C | K | V | L | E | L | Q | M | R | K | - | - | - | - | - | - | - | Mox1.rat | |
| 290 | Q | Q | E | V | V | - | - | - | I | T | K | V | V | S | H | P | S | G | V | L | E | L | H | M | K | K | - | - | - | - | - | - | - | mox2.human | |
| 270 | G | A | K | A | V | K | V | L | K | V | A | V | P | G | N | V | L | S | L | Y | M | S | K | P | K | G | F | K | Y | cytb558/arabidopsis.pep | | | | | |
| 263 | G | S | Y | S | V | R | L | L | K | V | A | I | Y | P | G | N | V | L | T | L | Q | M | S | K | P | P | T | F | R | Y | cytb558.rice.pep | | | | |

FIGURE 1(b)

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| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|------------------|-------------------------|---|-----------------|
| 319 | E | V | G | Q | Y | I | F | V | K | C | P | K | V | S | K | L | E | W | H | P | F | T | L | T | S | A | P | E | E | D | gp91phox.human | | |
| 320 | E | V | G | Q | Y | I | F | V | K | C | P | V | V | S | K | L | E | W | H | P | F | T | L | T | S | A | P | E | E | D | gp91phox.bovine | | |
| 320 | E | V | G | Q | Y | I | F | V | K | C | P | K | V | S | K | L | E | W | H | P | F | T | L | T | S | A | P | E | E | D | gp91phox.mouse | | |
| 320 | E | V | G | Q | Y | I | F | V | N | C | P | S | I | S | L | L | E | W | H | P | F | T | L | T | S | A | P | E | E | D | Mox1.human | | |
| 319 | G | I | G | Q | Y | I | F | V | N | C | P | S | I | S | F | L | E | W | H | P | F | T | L | T | S | A | P | E | E | E | Mox1.rat | | |
| 318 | A | P | G | Q | Y | I | L | V | Q | C | P | A | I | S | S | L | E | W | H | P | F | T | L | T | S | A | P | Q | E | D | mox2.human | | |
| 300 | T | S | G | Q | Y | I | Y | I | N | C | S | D | V | S | P | L | Q | W | H | P | F | S | I | T | S | A | S | G | D | D | cytb558/arabidopsis.pep | | |
| 293 | K | S | G | Q | Y | M | F | V | Q | C | P | A | V | S | P | F | E | W | H | P | F | S | I | T | S | A | P | G | D | D | cytb558.rice.pep | | |
| 349 | F | F | S | I | H | I | R | I | V | G | D | W | T | E | G | L | F | N | A | C | G | -- | C | -- | -- | -- | -- | -- | -- | -- | gp91phox.human | | |
| 350 | F | F | S | I | H | I | R | I | V | G | D | W | T | E | G | L | F | K | A | C | G | -- | C | -- | -- | -- | -- | -- | -- | -- | gp91phox.bovine | | |
| 350 | F | F | S | I | H | I | R | I | V | G | D | W | T | E | G | L | F | N | A | C | G | -- | C | -- | -- | -- | -- | -- | -- | -- | gp91phox.mouse | | |
| 350 | F | F | S | I | H | I | R | A | A | G | D | W | T | E | N | L | I | R | A | F | E | -- | -- | -- | -- | -- | -- | -- | -- | -- | Mox1.human | | |
| 349 | F | F | S | I | H | I | R | A | A | G | D | W | T | E | N | L | I | R | T | F | E | -- | -- | -- | -- | -- | -- | -- | -- | -- | Mox1.rat | | |
| 348 | F | F | S | V | H | I | R | A | A | G | D | W | T | A | A | L | L | E | A | F | G | -- | A | -- | -- | -- | -- | -- | -- | -- | mox2.human | | |
| 330 | Y | L | S | V | H | I | R | T | L | G | D | W | T | S | Q | L | K | S | L | Y | S | K | V | C | Q | L | P | S | T | S | cytb558/arabidopsis.pep | | |
| 323 | Y | L | S | I | H | V | R | Q | L | G | D | W | T | R | E | L | K | R | V | F | A | A | A | C | E | P | P | A | G | G | cytb558.rice.pep | | |
| 371 | -- | -- | -- | -- | -- | -- | -- | -- | -- | D | K | Q | E | F | Q | D | A | W | K | L | P | K | I | A | V | D | G | P | F | G | T | A | gp91phox.human |
| 372 | -- | -- | -- | -- | -- | -- | -- | -- | -- | D | K | Q | E | F | Q | D | A | W | K | L | P | K | I | A | V | D | G | P | F | G | T | A | gp91phox.bovine |
| 372 | -- | -- | -- | -- | -- | -- | -- | -- | -- | D | K | Q | E | F | Q | D | A | W | K | L | P | K | I | A | V | D | G | P | F | G | T | A | gp91phox.mouse |
| 371 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Mox1.human | | |
| 370 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Mox1.rat | | |
| 370 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | mox2.human | | |
| 360 | Q | S | G | L | F | I | A | D | I | G | Q | A | N | N | I | T | R | F | P | R | L | L | I | D | G | P | Y | G | A | P | cytb558/arabidopsis.pep | | |
| 353 | K | S | G | L | L | R | A | D | -- | E | T | T | K | K | I | -- | L | P | K | L | L | I | D | G | P | Y | G | S | P | cytb558.rice.pep | | | |
| 394 | S | E | D | V | F | S | Y | E | V | V | M | L | V | G | A | G | I | G | V | T | P | F | A | S | I | L | K | S | V | W | gp91phox.human | | |
| 395 | S | E | D | V | F | S | Y | E | V | V | M | L | V | G | A | G | I | G | V | T | P | F | A | S | I | L | K | S | V | W | gp91phox.bovine | | |
| 395 | S | E | D | V | F | S | Y | E | V | V | M | L | V | G | A | G | I | G | V | T | P | F | A | S | I | L | K | S | V | W | gp91phox.mouse | | |
| 389 | S | E | D | V | F | Q | Y | E | V | A | V | L | V | G | A | G | I | G | V | T | P | F | A | S | I | L | K | S | I | W | Mox1.human | | |
| 388 | S | E | D | V | F | Q | Y | E | V | A | V | L | V | G | A | G | I | G | V | T | P | F | A | S | F | L | K | S | I | W | Mox1.rat | | |
| 393 | L | T | D | V | F | H | Y | P | V | C | V | C | V | A | A | G | I | G | V | T | P | F | A | A | L | L | K | S | I | W | mox2.human | | |
| 390 | A | Q | D | Y | R | N | Y | D | V | L | L | L | V | G | L | G | I | G | A | T | P | L | I | S | I | I | R | D | V | L | cytb558/arabidopsis.pep | | |
| 380 | A | Q | D | Y | S | K | Y | D | V | L | L | L | V | G | L | G | I | G | A | T | P | F | I | S | I | L | K | D | L | L | cytb558.rice.pep | | |
| 424 | Y | K | Y | C | N | N | A | T | N | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | gp91phox.human | | |
| 425 | Y | K | Y | C | N | K | A | P | N | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | gp91phox.bovine | | |
| 425 | Y | K | Y | C | N | D | A | T | S | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | gp91phox.mouse | | |
| 419 | Y | K | F | Q | C | A | D | H | N | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Mox1.human | | |
| 418 | Y | K | F | Q | R | A | H | N | K | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Mox1.rat | | |
| 423 | Y | K | C | S | E | A | Q | T | P | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | mox2.human | | |
| 420 | N | N | I | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | cytb558/arabidopsis.pep | | |
| 410 | N | N | I | I | K | M | E | E | E | D | A | S | T | D | L | Y | P | P | M | G | R | N | N | P | H | V | D | L | G | cytb558.rice.pep | | | |
| 433 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | gp91phox.human | | |
| 434 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | gp91phox.bovine | | |
| 434 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | gp91phox.mouse | | |
| 428 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Mox1.human | | |
| 427 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | Mox1.rat | | |
| 432 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | mox2.human | | |
| 432 | T | N | Q | H | I | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | cytb558/arabidopsis.pep | | |
| 440 | T | L | M | T | I | T | S | R | P | K | K | I | L | K | T | T | N | A | Y | F | Y | W | V | T | R | E | Q | G | S | F | cytb558.rice.pep | | |

FIGURE 1(c)

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| | | | | |
|-----|-----------------------------|------------------|-------------------------|-------------------------|
| 451 | EWFADLLQLLESQMQRNNAGFLSY | --NIY | gp91phox.human | |
| 452 | EWFADLLQLLETQMQRNNAGFLSY | --NIC | gp91phox.bovine | |
| 452 | EWFADLLQLLETQMQRNNAGFLSY | --NIY | gp91phox.mouse | |
| 446 | SWFNNLLTSLLEQEMEELGKVGFLNY | --RLF | Mox1.human | |
| 445 | AWFNNLLTSLLEQEMDELGKPDFLNY | --RLF | Mox1.rat | |
| 450 | EWFADLLTSLLETQMSSEQGKTHFLSY | --HIF | mox2.human | |
| 458 | EWFSEVMNEV-AEYDSEGMIELHNY | CTSVY | cytb558/arabidopsis.pep | |
| 470 | DWEKGVMMNEI-ADLDQRNIEMHNY | LTSVY | cytb558.rice.pep | |
| 479 | LTG--WDESQANHFVHHDEEK | DVITGLK | gp91phox.human | |
| 480 | LTG--WDESQASHFAMHHDEEK | DVITGLK | gp91phox.bovine | |
| 480 | LTG--WDESQANHFVHHDEEK | DVITGLK | gp91phox.mouse | |
| 474 | LTG--WDSNIVGHAAALNFDKAT | DIVTGLK | Mox1.human | |
| 473 | LTG--WDSNIAGHAAALNFDRA | DVLTGLK | Mox1.rat | |
| 478 | LTG--WDENQALHIALHWDENT | DVITGLK | mox2.human | |
| 487 | EEGDARSALITMLQSLHHA | KSGIDIVSGTR | cytb558/arabidopsis.pep | |
| 499 | EEGDARSALITMLQALNHA | KNGVDIVSGTK | cytb558.rice.pep | |
| 506 | QKTLYGRPNWDNEFKTIAS | QHPNTRIGVFL | gp91phox.human | |
| 507 | QKTLYGRPNWDNEFKTIAS | QHPNTRIGVFL | gp91phox.bovine | |
| 507 | QKTLYGRPNWDNEFKTIAS | SEHPNTRIGVFL | gp91phox.mouse | |
| 501 | QKTSEFGRPMWDNEFS | STIATSHPKSVVG | VFLMox1.human | |
| 500 | QKTSEFGRPMWDNEFS | RIATAHPKSVVG | VFLMox1.rat | |
| 505 | QKTFYGRPNWNNEFKQIA | YNHPSSTIGVVF | mox2.human | |
| 517 | VRTHFARPNWRSVFKHVA | VNHVNQRVGVFY | cytb558/arabidopsis.pep | |
| 529 | VRTHFARPNWRKVL | SKISSKHPIYAKIGV | FYcytb558.rice.pep | |
| 536 | CGPEALAEATLSKQS | ISNSESGPRGVHFIFN | gp91phox.human | |
| 537 | CGPEALAEATLSKQS | ISNSDSGPRGVHFIFN | gp91phox.bovine | |
| 537 | CGPEALAEATLSKQS | ISNSESGPRGVHFIFN | gp91phox.mouse | |
| 531 | CGPRTLAKSLRKCC | HRYS | SLDPRKVQFYFN | Mox1.human |
| 530 | CGPRTLAKSLRKCC | RRYS | SLDPRKVQFYFN | Mox1.rat |
| 535 | CGPKALSRRTLQKM | CHLYS | SADPRGVHFYFN | mox2.human |
| 547 | CGNTCIIGELKRLA | QDFSRKT | --TTKFEFH | cytb558/arabidopsis.pep |
| 559 | CGAPVLAQELSKL | CHEFNGKC | --TTKFEFH | cytb558.rice.pep |
| 566 | KENF | | gp91phox.human | |
| 567 | KENF | | gp91phox.bovine | |
| 567 | KENF | | gp91phox.mouse | |
| 561 | KEN-F | | Mox1.human | |
| 560 | KETF | | Mox1.rat | |
| 565 | KESF | | mox2.human | |
| 575 | KENF | | cytb558/arabidopsis.pep | |
| 587 | KEHF | | cytb558.rice.pep | |

Decoration 'Decoration #1': Box residues that match the Consensus exactly.

FIGURE 1(d)

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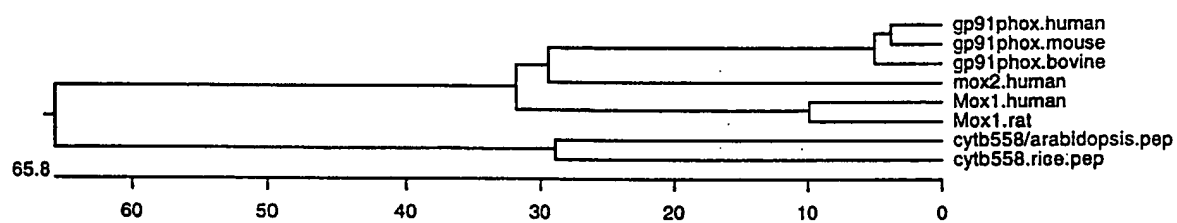


FIGURE 2

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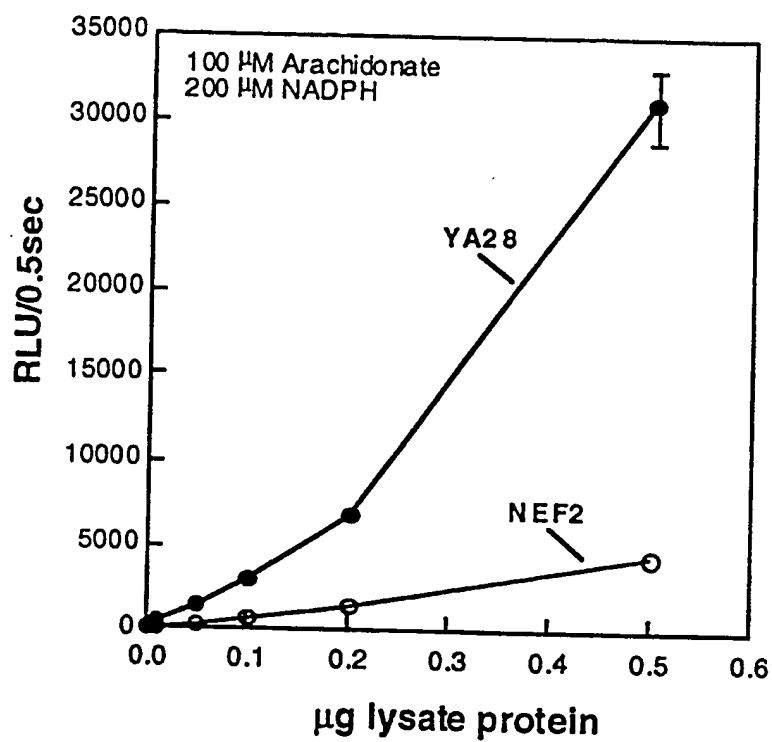


FIGURE 3

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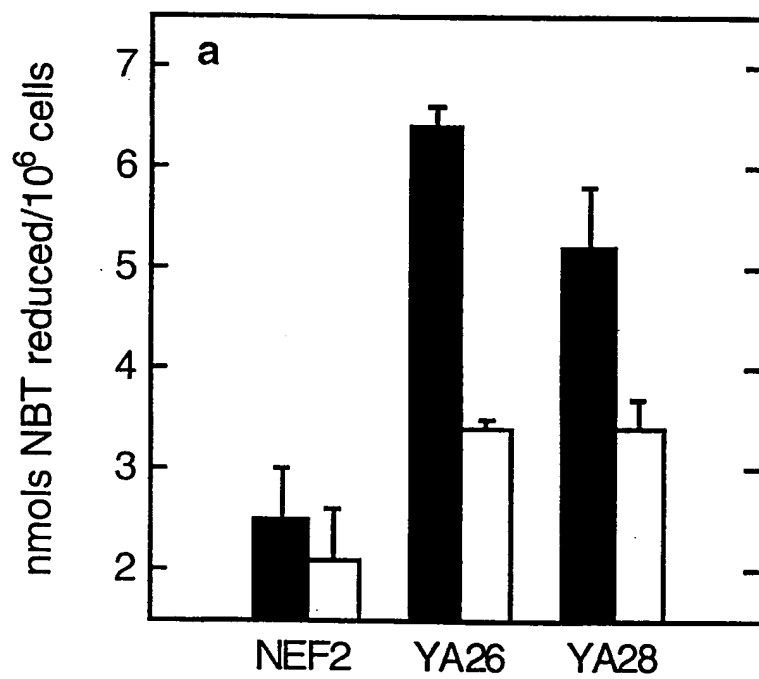


FIGURE 4

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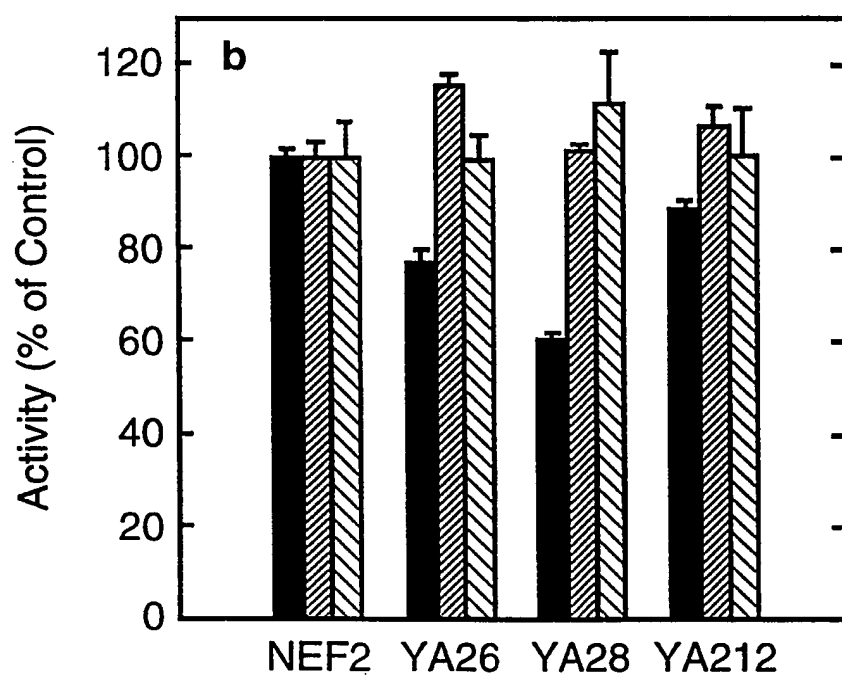


FIGURE 5

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10

15

20

25

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Phe Val Asp Ala Phe Leu Lys Tyr Glu Lys Ala Asp Lys Tyr Tyr Tyr

30

35

40

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Thr Arg Lys Ile Leu Gly Ser Thr Leu Ala Cys Ala Arg Ala Ser Ala

45

50

55

ctc tgc ttg aat ttt aac agc acg ctg atc ctg ctt cct gtg tgt cgc 425

| | |
|---|------|
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| 60 65 70 | |
| aat ctg ctg tcc ttc ctg agg ggc acc tgc tca ttt tgc agc cgc aca | 473 |
| Asn Leu Leu Ser Phe Leu Arg Gly Thr Cys Ser Phe Cys Ser Arg Thr | |
| 75 80 85 | |
| ctg aga aag caa ttg gat cac aac ctc acc ttc cac aag ctg gtg gcc | 521 |
| Leu Arg Lys Gln Leu Asp His Asn Leu Thr Phe His Lys Leu Val Ala | |
| 90 95 100 105 | |
| tat atg atc tgc cta cat aca gct att cac atc att gca cac ctg ttt | 569 |
| Tyr Met Ile Cys Leu His Thr Ala Ile His Ile Ile Ala His Leu Phe | |
| 110 115 120 | |
| aac ttt gac tgc tat agc aga agc cga cag gcc aca gat ggc tcc ctt | 617 |
| Asn Phe Asp Cys Tyr Ser Arg Ser Arg Gln Ala Thr Asp Gly Ser Leu | |
| 125 130 135 | |
| gcc tcc att ctc tcc agc cta tct cat gat gag aaa aag ggg ggt tct | 665 |
| Ala Ser Ile Leu Ser Ser Leu Ser His Asp Glu Lys Lys Gly Gly Ser | |
| 140 145 150 | |
| tgg cta aat ccc atc cag tcc cga aac acg aca gtg gag tat gtg aca | 713 |
| Trp Leu Asn Pro Ile Gln Ser Arg Asn Thr Thr Val Glu Tyr Val Thr | |
| 155 160 165 | |
| ttc acc agc gtt gct ggt ctc act gga gtg atc atg aca ata gcc ttg | 761 |
| Phe Thr Ser Val Ala Gly Leu Thr Gly Val Ile Met Thr Ile Ala Leu | |
| 170 175 180 185 | |
| att ctc atg gta act tca gct act gag ttc atc cgg agg agt tat ttt | 809 |
| Ile Leu Met Val Thr Ser Ala Thr Glu Phe Ile Arg Arg Ser Tyr Phe | |
| 190 195 200 | |
| gaa gtc ttc tgg tat act cac cac ctt ttt atc ttc tat atc ctt ggc | 857 |
| Glu Val Phe Trp Tyr Thr His His Leu Phe Ile Phe Tyr Ile Leu Gly | |
| 205 210 215 | |
| tta ggg att cac ggc att ggt gga att gtc cgg ggt caa aca gag gag | 905 |
| Leu Gly Ile His Gly Ile Gly Gly Ile Val Arg Gly Gln Thr Glu Glu | |
| 220 225 230 | |
| agc atg aat gag agt cat cct cgc aag tgt gca gag tct ttt gag atg | 953 |
| Ser Met Asn Glu Ser His Pro Arg Lys Cys Ala Glu Ser Phe Glu Met | |
| 235 240 245 | |
| tgg gat gat cgt gac tcc cac tgt agg cgc cct aag ttt gaa ggg cat | 1001 |

3

Thr Gly Ala Phe Ser Trp Phe Asn Asn Leu Leu Thr Ser Leu Glu Gln
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 Glu Met Glu Glu Leu Gly Lys Val Gly Phe Leu Asn Tyr Arg Leu Phe
 460 465 470
 ctc acc gga tgg gac agc aat att gtt ggt cat gca gca tta aac ttt 1673
 Leu Thr Gly Trp Asp Ser Asn Ile Val Gly His Ala Ala Leu Asn Phe
 475 480 485
 gac aag gcc act gac atc gtg aca ggt ctg aaa cag aaa acc tcc ttt 1721
 Asp Lys Ala Thr Asp Ile Val Thr Gly Leu Lys Gln Lys Thr Ser Phe
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 Gly Arg Pro Met Trp Asp Asn Glu Phe Ser Thr Ile Ala Thr Ser His
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 Lys Ser Leu Arg Lys Cys Cys His Arg Tyr Ser Ser Leu Asp Pro Arg
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 Lys Val Gln Phe Tyr Phe Asn Lys Glu Asn Phe
 555 560 565
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 Tyr Glu Lys Ala Asp Lys Tyr Tyr Tyr Thr Arg Lys Ile Leu Gly Ser
 35 40 45
 Thr Leu Ala Cys Ala Arg Ala Ser Ala Leu Cys Leu Asn Phe Asn Ser
 50 55 60
 Thr Leu Ile Leu Leu Pro Val Cys Arg Asn Leu Leu Ser Phe Leu Arg
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 Gly Thr Cys Ser Phe Cys Ser Arg Thr Leu Arg Lys Gln Leu Asp His
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 Asn Leu Thr Phe His Lys Leu Val Ala Tyr Met Ile Cys Leu His Thr
 100 105 110
 Ala Ile His Ile Ile Ala His Leu Phe Asn Phe Asp Cys Tyr Ser Arg
 115 120 125
 Ser Arg Gln Ala Thr Asp Gly Ser Leu Ala Ser Ile Leu Ser Ser Leu
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 Ser His Asp Glu Lys Lys Gly Gly Ser Trp Leu Asn Pro Ile Gln Ser
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 Arg Asn Thr Thr Val Glu Tyr Val Thr Phe Thr Ser Val Ala Gly Leu
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 Thr Gly Val Ile Met Thr Ile Ala Leu Ile Leu Met Val Thr Ser Ala

| | | |
|---|-----|-----|
| 180 | 185 | 190 |
| Thr Glu Phe Ile Arg Arg Ser Tyr Phe Glu Val Phe Trp Tyr Thr His | | |
| 195 | 200 | 205 |
| His Leu Phe Ile Phe Tyr Ile Leu Gly Leu Gly Ile His Gly Ile Gly | | |
| 210 | 215 | 220 |
| Gly Ile Val Arg Gly Gln Thr Glu Glu Ser Met Asn Glu Ser His Pro | | |
| 225 | 230 | 235 |
| | | 240 |
| Arg Lys Cys Ala Glu Ser Phe Glu Met Trp Asp Asp Arg Asp Ser His | | |
| 245 | 250 | 255 |
| Cys Arg Arg Pro Lys Phe Glu Gly His Pro Pro Glu Ser Trp Lys Trp | | |
| 260 | 265 | 270 |
| Ile Leu Ala Pro Val Ile Leu Tyr Ile Cys Glu Arg Ile Leu Arg Phe | | |
| 275 | 280 | 285 |
| Tyr Arg Ser Gln Gln Lys Val Val Ile Thr Lys Val Val Met His Pro | | |
| 290 | 295 | 300 |
| Ser Lys Val Leu Glu Leu Gln Met Asn Lys Arg Gly Phe Ser Met Glu | | |
| 305 | 310 | 315 |
| | | 320 |
| Val Gly Gln Tyr Ile Phe Val Asn Cys Pro Ser Ile Ser Leu Leu Glu | | |
| 325 | 330 | 335 |
| Trp His Pro Phe Thr Leu Thr Ser Ala Pro Glu Glu Asp Phe Phe Ser | | |
| 340 | 345 | 350 |
| Ile His Ile Arg Ala Ala Gly Asp Trp Thr Glu Asn Leu Ile Arg Ala | | |
| 355 | 360 | 365 |
| Phe Glu Gln Gln Tyr Ser Pro Ile Pro Arg Ile Glu Val Asp Gly Pro | | |
| 370 | 375 | 380 |
| Phe Gly Thr Ala Ser Glu Asp Val Phe Gln Tyr Glu Val Ala Val Leu | | |
| 385 | 390 | 395 |
| | | 400 |
| Val Gly Ala Gly Ile Gly Val Thr Pro Phe Ala Ser Ile Leu Lys Ser | | |
| 405 | 410 | 415 |
| Ile Trp Tyr Lys Phe Gln Cys Ala Asp His Asn Leu Lys Thr Lys Lys | | |
| 420 | 425 | 430 |
| Ile Tyr Phe Tyr Trp Ile Cys Arg Glu Thr Gly Ala Phe Ser Trp Phe | | |

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| 25 | 30 | 35 | |
|--|-----|-----|-----|
| gag gag tct ttc cat tac aca cga gtt att ttg ggt tca aca ctg gct | | | 259 |
| Glu Glu Ser Phe His Tyr Thr Arg Val Ile Leu Gly Ser Thr Leu Ala | | | |
| 40 | 45 | 50 | |
| tggt gca cga gca tcc gca ctg tgc ctg aat ttt aac tgc atg cta att | | | 307 |
| Trp Ala Arg Ala Ser Ala Leu Cys Leu Asn Phe Asn Cys Met Leu Ile | | | |
| 55 | 60 | 65 | |
| cta ata cct gtc agt cga aac ctt att tca ttc ata aga gga aca agt | | | 355 |
| Leu Ile Pro Val Ser Arg Asn Leu Ile Ser Phe Ile Arg Gly Thr Ser | | | |
| 70 | 75 | 80 | |
| att tgc tgc aga gga ccg tgg agg agg caa tta gac aaa aac ctc aga | | | 403 |
| Ile Cys Cys Arg Gly Pro Trp Arg Arg Gln Leu Asp Lys Asn Leu Arg | | | |
| 85 | 90 | 95 | 100 |
| ttt cac aaa ctg gtc gcc tat ggg ata gct gtt aat gca acc atc cac | | | 451 |
| Phe His Lys Leu Val Ala Tyr Gly Ile Ala Val Asn Ala Thr Ile His | | | |
| 105 | 110 | 115 | |
| atc gtg gcg cat ttc ttc aac ctg gaa cgc tac cac tgg agc cag tcc | | | 499 |
| Ile Val Ala His Phe Phe Asn Leu Glu Arg Tyr His Trp Ser Gln Ser | | | |
| 120 | 125 | 130 | |
| gag gag gcc cag gga ctt ctg gcc gca ctt tcc aag ctg ggc aac acc | | | 547 |
| Glu Glu Ala Gln Gly Leu Leu Ala Ala Leu Ser Lys Leu Gly Asn Thr | | | |
| 135 | 140 | 145 | |
| cct aac gag agc tac ctc aac cct gtc cgg acc ttc ccc aca aac aca | | | 595 |
| Pro Asn Glu Ser Tyr Leu Asn Pro Val Arg Thr Phe Pro Thr Asn Thr | | | |
| 150 | 155 | 160 | |
| acc act gaa ttg cta agg aca ata gca ggc gtc acc ggt ctg gtg atc | | | 643 |
| Thr Thr Glu Leu Leu Arg Thr Ile Ala Gly Val Thr Gly Leu Val Ile | | | |
| 165 | 170 | 175 | 180 |
| tct ctg gct tta gtc ttg atc atg acc tcg tca act gag ttc atc aga | | | 691 |
| Ser Leu Ala Leu Val Leu Ile Met Thr Ser Ser Thr Glu Phe Ile Arg | | | |
| 185 | 190 | 195 | |
| cag gcc tcc tat gag ttg ttc tgg tac aca cac cat gtt ttc atc gtc | | | 739 |
| Gln Ala Ser Tyr Glu Leu Phe Trp Tyr Thr His His Val Phe Ile Val | | | |
| 200 | 205 | 210 | |
| ttc ttt ctc agc ctg gcc atc cat ggg acg ggt cgg att gtt cga ggc | | | 787 |
| Phe Phe Leu Ser Leu Ala Ile His Gly Thr Gly Arg Ile Val Arg Gly | | | |

| 215 | 220 | 225 | |
|---|-----|-----|------|
| caa acc caa gac agt ctc tct ctg cac aac atc acc ttc tgt aga gac | | | 835 |
| Gln Thr Gln Asp Ser Leu Ser Leu His Asn Ile Thr Phe Cys Arg Asp | | | |
| 230 | 235 | 240 | |
| cgc tat gca gaa tgg cag aca gtg gcc caa tgc ccc gtg cct caa ttt | | | 883 |
| Arg Tyr Ala Glu Trp Gln Thr Val Ala Gln Cys Pro Val Pro Gln Phe | | | |
| 245 | 250 | 255 | 260 |
| tct ggc aag gaa ccc tcg gct tgg aaa tgg att tta ggc cct gtg gtc | | | 931 |
| Ser Gly Lys Glu Pro Ser Ala Trp Lys Trp Ile Leu Gly Pro Val Val | | | |
| 265 | 270 | 275 | |
| ttg tat gca tgt gaa aga ata att agg ttc tgg cga ttt caa caa gaa | | | 979 |
| Leu Tyr Ala Cys Glu Arg Ile Ile Arg Phe Trp Arg Phe Gln Gln Glu | | | |
| 280 | 285 | 290 | |
| gtt gtc att acc aag gtg gta agc cac ccc tct gga gtc ctg gaa ctt | | | 1027 |
| Val Val Ile Thr Lys Val Val Ser His Pro Ser Gly Val Leu Glu Leu | | | |
| 295 | 300 | 305 | |
| cac atg aaa aag cgt ggc ttt aaa atg gcg cca ggg cag tac atc ttg | | | 1075 |
| His Met Lys Lys Arg Gly Phe Lys Met Ala Pro Gly Gln Tyr Ile Leu | | | |
| 310 | 315 | 320 | |
| gtg cag tgc cca gcc ata tct tcg ctg gag tgg cac ccc ttc acc ctt | | | 1123 |
| Val Gln Cys Pro Ala Ile Ser Ser Leu Glu Trp His Pro Phe Thr Leu | | | |
| 325 | 330 | 335 | 340 |
| acc tct gcc ccc cag gaa gac ttt ttc agc gtg cac atc cgg gca gca | | | 1171 |
| Thr Ser Ala Pro Gln Glu Asp Phe Phe Ser Val His Ile Arg Ala Ala | | | |
| 345 | 350 | 355 | |
| gga gac tgg aca gca gcg cta ctg gag gcc ttt ggg gca gag gga cag | | | 1219 |
| Gly Asp Trp Thr Ala Ala Leu Leu Glu Ala Phe Gly Ala Glu Gly Gln | | | |
| 360 | 365 | 370 | |
| gcc ctc cag gag ccc tgg agc ctg cca agg ctg gca gtg gac ggg ccc | | | 1267 |
| Ala Leu Gln Glu Pro Trp Ser Leu Pro Arg Leu Ala Val Asp Gly Pro | | | |
| 375 | 380 | 385 | |
| ttt gga act gcc ctg aca gat gta ttt cac tac cca gtg tgt gtg tgc | | | 1315 |
| Phe Gly Thr Ala Leu Thr Asp Val Phe His Tyr Pro Val Cys Val Cys | | | |
| 390 | 395 | 400 | |
| gtt gcc gcg ggg atc gga gtc act ccc ttc gct gct ctt ctg aaa tct | | | 1363 |
| Val Ala Ala Gly Ile Gly Val Thr Pro Phe Ala Ala Leu Leu Lys Ser | | | |

| 405 | 410 | 415 | 420 | |
|--|-----|-----|-----|------|
| ata tgg tac aaa tgc agt gag gca cag acc cca ctg aag ctg agc aag | | | | 1411 |
| Ile Trp Tyr Lys Cys Ser Glu Ala Gln Thr Pro Leu Lys Leu Ser Lys | | | | |
| 425 | | 430 | 435 | |
| gtg tat ttc tac tgg att tgc cgg gat gca aga gct ttt gag tgg ttt | | | | 1459 |
| Val Tyr Phe Tyr Trp Ile Cys Arg Asp Ala Arg Ala Phe Glu Trp Phe | | | | |
| 440 | 445 | | 450 | |
| gct gat ctc tta ctc tcc ctg gaa aca cgg atg agt gag cag ggg aaa | | | | 1507 |
| Ala Asp Leu Leu Leu Ser Leu Glu Thr Arg Met Ser Glu Gln Gly Lys | | | | |
| 455 | 460 | | 465 | |
| act cac ttt ctg agt tat cat ata ttt ctt acc ggc tgg gat gaa aat | | | | 1555 |
| Thr His Phe Leu Ser Tyr His Ile Phe Leu Thr Gly Trp Asp Glu Asn | | | | |
| 470 | 475 | | 480 | |
| cag gct ctt cac ata gct tta cac tgg gac gaa aat act gac gtg att | | | | 1603 |
| Gln Ala Leu His Ile Ala Leu His Trp Asp Glu Asn Thr Asp Val Ile | | | | |
| 485 | 490 | 495 | 500 | |
| aca ggc tta aag cag aag acc ttc tat ggg agg ccc aac tgg aac aat | | | | 1651 |
| Thr Gly Leu Lys Gln Lys Thr Phe Tyr Gly Arg Pro Asn Trp Asn Asn | | | | |
| 505 | 510 | | 515 | |
| gag ttc aag cag att gcc tac aat cac ccc agc agc agt att ggc gtg | | | | 1699 |
| Glu Phe Lys Gln Ile Ala Tyr Asn His Pro Ser Ser Ser Ile Gly Val | | | | |
| 520 | 525 | | 530 | |
| ttc ttc tgt gga cct aaa gct ctc tcg agg aca ctt caa aag atg tgc | | | | 1747 |
| Phe Phe Cys Gly Pro Lys Ala Leu Ser Arg Thr Leu Gln Lys Met Cys | | | | |
| 535 | 540 | | 545 | |
| cac ttg tat tca tca gct gac ccc aga ggt gtt cat ttc tat tac aac | | | | 1795 |
| His Leu Tyr Ser Ser Ala Asp Pro Arg Gly Val His Phe Tyr Tyr Asn | | | | |
| 550 | 555 | | 560 | |
| aag gag agc ttc tag actttggagg tcaagtccag gcattgtggt ttcaatcaag | | | | 1850 |
| Lys Glu Ser Phe | | | | |
| 565 | | | | |
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| agttgggaac tgggtgaataa taattaacta ttgtgaacag tacactatac catacttcct | | | | 1970 |
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Trp Tyr Glu Glu Glu Glu Ser Phe His Tyr Thr Arg Val Ile Leu Gly
 35 40 45

Ser Thr Leu Ala Trp Ala Arg Ala Ser Ala Leu Cys Leu Asn Phe Asn
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Cys Met Leu Ile Leu Ile Pro Val Ser Arg Asn Leu Ile Ser Phe Ile
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Arg Gly Thr Ser Ile Cys Cys Arg Gly Pro Trp Arg Arg Gln Leu Asp
 85 90 95

Lys Asn Leu Arg Phe His Lys Leu Val Ala Tyr Gly Ile Ala Val Asn
 100 105 110

Ala Thr Ile His Ile Val Ala His Phe Phe Asn Leu Glu Arg Tyr His
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Trp Ser Gln Ser Glu Glu Ala Gln Gly Leu Leu Ala Ala Leu Ser Lys
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Leu Gly Asn Thr Pro Asn Glu Ser Tyr Leu Asn Pro Val Arg Thr Phe
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Pro Thr Asn Thr Thr Thr Glu Leu Leu Arg Thr Ile Ala Gly Val Thr
 165 170 175

Gly Leu Val Ile Ser Leu Ala Leu Val Leu Ile Met Thr Ser Ser Thr
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Glu Phe Ile Arg Gln Ala Ser Tyr Glu Leu Phe Trp Tyr Thr His His
 195 200 205

Val Phe Ile Val Phe Phe Leu Ser Leu Ala Ile His Gly Thr Gly Arg
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 Ile Val Arg Gly Gln Thr Gln Asp Ser Leu Ser Leu His Asn Ile Thr
 225 230 235 240
 Phe Cys Arg Asp Arg Tyr Ala Glu Trp Gln Thr Val Ala Gln Cys Pro
 245 250 255
 Val Pro Gln Phe Ser Gly Lys Glu Pro Ser Ala Trp Lys Trp Ile Leu
 260 265 270
 Gly Pro Val Val Leu Tyr Ala Cys Glu Arg Ile Ile Arg Phe Trp Arg
 275 280 285
 Phe Gln Gln Glu Val Val Ile Thr Lys Val Val Ser His Pro Ser Gly
 290 295 300
 Val Leu Glu Leu His Met Lys Lys Arg Gly Phe Lys Met Ala Pro Gly
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 Ile Arg Ala Ala Gly Asp Trp Thr Ala Ala Leu Leu Glu Ala Phe Gly
 355 360 365
 Ala Glu Gly Gln Ala Leu Gln Glu Pro Trp Ser Leu Pro Arg Leu Ala
 370 375 380
 Val Asp Gly Pro Phe Gly Thr Ala Leu Thr Asp Val Phe His Tyr Pro
 385 390 395 400
 Val Cys Val Cys Val Ala Ala Gly Ile Gly Val Thr Pro Phe Ala Ala
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 435 440 445
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Glu Gln Gly Lys Thr His Phe Leu Ser Tyr His Ile Phe Leu Thr Gly
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Trp Asp Glu Asn Gln Ala Leu His Ile Ala Leu His Trp Asp Glu Asn
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Thr Asp Val Ile Thr Gly Leu Lys Gln Lys Thr Phe Tyr Gly Arg Pro
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Asn Trp Asn Asn Glu Phe Lys Gln Ile Ala Tyr Asn His Pro Ser Ser
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Ser Ile Gly Val Phe Phe Cys Gly Pro Lys Ala Leu Ser Arg Thr Leu
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Phe Tyr Tyr Asn Lys Glu Ser Phe
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<212> DNA

<213> Artificial Sequence

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<211> 20

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ttgtaccaga tggatttcaa

20

<210> 9

<211> 21

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 9

caggtctgaa acagaaaacc t

21

<210> 10

<211> 27

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 10

atgaattctc attaattatt caataaa

27

<210> 11

<211> 20

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 11

atctcaaaag actctgcaca

20

<210> 12

<211> 569

<212> PRT

<213> Homo sapiens

<400> 12

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Gly | Asn | Trp | Ala | Val | Asn | Glu | Gly | Leu | Ser | Ile | Phe | Ala | Ile | Leu | Val |
| 1 | | | | 5 | | | | | 10 | | | | | 15 | |

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Trp | Leu | Gly | Leu | Asn | Val | Phe | Leu | Phe | Val | Trp | Tyr | Tyr | Arg | Val | Tyr |
| | | | 20 | | | | | | 25 | | | | | 30 | |

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Asp | Ile | Pro | Pro | Lys | Phe | Phe | Tyr | Thr | Arg | Lys | Leu | Leu | Gly | Ser | Ala |
| | | 35 | | | | | 40 | | | | | | 45 | | |

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Leu | Ala | Leu | Ala | Arg | Ala | Pro | Ala | Ala | Cys | Leu | Asn | Phe | Asn | Cys | Met |
| | 50 | | | | | 55 | | | | | | | 60 | | |

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Leu | Ile | Leu | Leu | Pro | Val | Cys | Arg | Asn | Leu | Leu | Ser | Phe | Leu | Arg | Gly |
| 65 | | | | | 70 | | | | | 75 | | | | | 80 |

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ser | Ser | Ala | Cys | Cys | Ser | Thr | Arg | Val | Arg | Arg | Gln | Leu | Asp | Arg | Asn |
| | | | | 85 | | | | | 90 | | | | | 95 | |

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Leu | Thr | Phe | His | Lys | Met | Val | Ala | Trp | Met | Ile | Ala | Leu | His | Ser | Ala |
| | | | 100 | | | | | | 105 | | | | | 110 | |

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ile | His | Thr | Ile | Ala | His | Leu | Phe | Asn | Val | Glu | Trp | Cys | Val | Asn | Ala |
| | | 115 | | | | | | 120 | | | | | 125 | | |

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Arg | Val | Asn | Asn | Ser | Asp | Pro | Tyr | Ser | Val | Ala | Leu | Ser | Glu | Leu | Gly |
| | 130 | | | | | 135 | | | | | | 140 | | | |

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Asp | Arg | Gln | Asn | Glu | Ser | Tyr | Leu | Asn | Phe | Ala | Arg | Lys | Arg | Ile | Lys |
| 145 | | | | | 150 | | | | | 155 | | | | | 160 |

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Asn | Pro | Glu | Gly | Gly | Leu | Tyr | Leu | Ala | Val | Thr | Leu | Leu | Ala | Gly | Ile |
| | | | 165 | | | | | | 170 | | | | | 175 | |

Thr Gly Val Val Ile Thr Leu Cys Leu Ile Leu Ile Ile Thr Ser Ser
 180 185 190

Thr Lys Thr Ile Arg Arg Ser Tyr Phe Glu Val Phe Trp Tyr Thr His
 195 200 205

His Leu Phe Val Ile Phe Phe Ile Gly Leu Ala Ile His Gly Ala Glu
 210 215 220

Arg Ile Val Arg Gly Gln Thr Ala Glu Ser Leu Ala Val His Asn Ile
 225 230 235 240

Thr Val Cys Glu Gln Lys Ile Ser Glu Trp Gly Lys Ile Lys Glu Cys
 245 250 255

Pro Ile Pro Gln Phe Ala Gly Asn Pro Pro Met Thr Trp Lys Trp Ile
 260 265 270

Val Gly Pro Met Phe Leu Tyr Leu Cys Glu Arg Leu Val Arg Phe Trp
 275 280 285

Arg Ser Gln Gln Lys Val Val Ile Thr Lys Val Val Thr His Pro Phe
 290 295 300

Lys Thr Ile Glu Leu Gln Met Lys Lys Lys Gly Phe Lys Met Glu Val
 305 310 315 320

Gly Gln Tyr Ile Phe Val Lys Cys Pro Lys Val Ser Lys Leu Glu Trp
 325 330 335

His Pro Phe Thr Leu Thr Ser Ala Pro Glu Glu Asp Phe Phe Ser Ile
 340 345 350

His Ile Arg Ile Val Gly Asp Trp Thr Glu Gly Leu Phe Asn Ala Cys
 355 360 365

Gly Cys Asp Lys Gln Glu Phe Gln Asp Ala Trp Lys Leu Pro Lys Ile
 370 375 380

Ala Val Asp Gly Pro Phe Gly Thr Ala Ser Glu Asp Val Phe Ser Tyr
 385 390 395 400

Glu Val Val Met Leu Val Gly Ala Gly Ile Gly Val Thr Pro Phe Ala
 405 410 415

Ser Ile Leu Lys Ser Val Trp Tyr Lys Tyr Cys Asn Asn Ala Thr Asn
 420 425 430

Leu Lys Leu Lys Lys Ile Tyr Phe Tyr Trp Leu Cys Arg Asp Thr His
 435 440 445

Ala Phe Glu Trp Phe Ala Asp Leu Leu Gln Leu Leu Glu Ser Gln Met
 450 455 460

Gln Glu Arg Asn Asn Ala Gly Phe Leu Ser Tyr Asn Ile Tyr Leu Thr
 465 470 475 480

Gly Trp Asp Glu Ser Gln Ala Asn His Phe Ala Val His His Asp Glu
 485 490 495

Glu Lys Asp Val Ile Thr Gly Leu Lys Gln Lys Thr Leu Tyr Gly Arg
 500 505 510

Pro Asn Trp Asp Asn Glu Phe Lys Thr Ile Ala Ser Gln His Pro Asn
 515 520 525

Thr Arg Ile Gly Val Phe Leu Cys Gly Pro Glu Ala Leu Ala Glu Thr
 530 535 540

Leu Ser Lys Gln Ser Ile Ser Asn Ser Glu Ser Gly Pro Arg Gly Val
 545 550 555 560

His Phe Ile Phe Asn Lys Glu Asn Phe
 565

<210> 13

<211> 18

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 13

ttggctaaat cccatcca

18

<210> 14

<211> 21

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 14
tgcattgacca acaatattgc t

21

<210> 15
<211> 27
<212> DNA
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: primer

<400> 15
caaggtagctt cttgaccatg ggaaact

27

<210> 16
<211> 27
<212> DNA
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: primer

<400> 16
acgaattcaa gtaaattact gaagata

27

<210> 17
<211> 26
<212> DNA
<213> Artificial Sequence

<220>
<221> modified_base
<222> ()..)
<223> n at position 3 = inosine

<220>
<221> modified_base
<222> ()
<223> n at position 6 = inosine

<220>
<221> modified_base
<222> ()
<223> n at position 12 = inosine

<220>

<223> Description of Artificial Sequence: primer

<400> 17

ccngtntgtc gnaatctgct stcctt

26

<210> 18

<211> 29

<212> DNA

<213> Artificial Sequence

<220>

<221> modified_base

<222> (5)

<223> n at position 5 = inosine

<220>

<221> modified_base

<222> (9)

<223> n at position 9 = inosine

<220>

<221> modified_base

<222> (11)

<223> n at position 11 = inosine

<220>

<223> Description of Artificial Sequence: primer

<400> 18

tcccngcana nccagtagaa rtagatctt

29

<210> 19

<211> 26

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 19

ttggcacagt cagtgaggat gtcttc

26

<210> 20

<211> 30
 <212> DNA
 <213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 20
 ctgttggtt ctactgtac gttcaaagtt

30

<210> 21
 <211> 563
 <212> PRT
 <213> Rat

<400> 21

Met Gly Asn Trp Leu Val Asn His Trp Leu Ser Val Leu Phe Leu Val
 1 5 10 15

Ser Trp Leu Gly Leu Asn Ile Phe Leu Phe Val Tyr Val Phe Leu Asn
 20 25 30

Tyr Glu Lys Ser Asp Lys Tyr Tyr Tyr Thr Arg Glu Ile Leu Gly Thr
 35 40 45

Ala Leu Ala Leu Ala Arg Ala Ser Ala Leu Cys Leu Asn Phe Asn Ser
 50 55 60

Met Val Ile Leu Ile Pro Val Cys Arg Asn Leu Leu Ser Phe Leu Arg
 65 70 75 80

Gly Thr Cys Ser Phe Cys Asn His Thr Leu Arg Lys Pro Leu Asp His
 85 90 95

Asn Leu Thr Phe His Lys Leu Val Ala Tyr Met Ile Cys Ile Phe Thr
 100 105 110

Ala Ile His Ile Ile Ala His Leu Phe Asn Phe Glu Arg Tyr Ser Arg
 115 120 125

Ser Gln Gln Ala Met Asp Gly Ser Leu Ala Ser Val Leu Ser Ser Leu
 130 135 140

Phe His Pro Glu Lys Glu Asp Ser Trp Leu Asn Pro Ile Gln Ser Pro
 145 150 155 160

Asn Val Thr Val Met Tyr Ala Ala Phe Thr Ser Ile Ala Gly Leu Thr

| | | | | | |
|---|-----|-----|-----|-----|-----|
| | 165 | | 170 | | 175 |
| Gly Val Val Ala Thr Val Ala Leu Val Leu Met Val Thr Ser Ala Met | | | | | |
| 180 | | 185 | | 190 | |
| Glu Phe Ile Arg Arg Asn Tyr Phe Glu Leu Phe Trp Tyr Thr His His | | | | | |
| 195 | | 200 | | 205 | |
| Leu Phe Ile Ile Tyr Ile Ile Cys Leu Gly Ile His Gly Leu Gly Gly | | | | | |
| 210 | | 215 | | 220 | |
| Ile Val Arg Gly Gln Thr Glu Glu Ser Met Ser Glu Ser His Pro Arg | | | | | |
| 225 | | 230 | | 235 | 240 |
| Asn Cys Ser Tyr Ser Phe His Glu Trp Asp Lys Tyr Glu Arg Ser Cys | | | | | |
| | 245 | | 250 | | 255 |
| Arg Ser Pro His Phe Val Gly Gln Pro Pro Glu Ser Trp Lys Trp Ile | | | | | |
| | 260 | | 265 | | 270 |
| Leu Ala Pro Ile Ala Phe Tyr Ile Phe Glu Arg Ile Leu Arg Phe Tyr | | | | | |
| | 275 | | 280 | | 285 |
| Arg Ser Arg Gln Lys Val Val Ile Thr Lys Val Val Met His Pro Cys | | | | | |
| | 290 | | 295 | | 300 |
| Lys Val Leu Glu Leu Gln Met Arg Lys Arg Gly Phe Thr Met Gly Ile | | | | | |
| 305 | | 310 | | 315 | 320 |
| Gly Gln Tyr Ile Phe Val Asn Cys Pro Ser Ile Ser Phe Leu Glu Trp | | | | | |
| | 325 | | 330 | | 335 |
| His Pro Phe Thr Leu Thr Ser Ala Pro Glu Glu Glu Phe Phe Ser Ile | | | | | |
| | 340 | | 345 | | 350 |
| His Ile Arg Ala Ala Gly Asp Trp Thr Glu Asn Leu Ile Arg Thr Phe | | | | | |
| | 355 | | 360 | | 365 |
| Glu Gln Gln His Ser Pro Met Pro Arg Ile Glu Val Asp Gly Pro Phe | | | | | |
| | 370 | | 375 | | 380 |
| Gly Thr Val Ser Glu Asp Val Phe Gln Tyr Glu Val Ala Val Leu Val | | | | | |
| 385 | | 390 | | 395 | 400 |
| Gly Ala Gly Ile Gly Val Thr Pro Phe Ala Ser Phe Leu Lys Ser Ile | | | | | |
| | 405 | | 410 | | 415 |
| Trp Tyr Lys Phe Gln Arg Ala His Asn Lys Leu Lys Thr Gln Lys Ile | | | | | |

420 425 430
 Tyr Phe Tyr Trp Ile Cys Arg Glu Thr Gly Ala Phe Ala Trp Phe Asn
 435 440 445
 Asn Leu Leu Asn Ser Leu Glu Gln Glu Met Asp Glu Leu Gly Lys Pro
 450 455 460
 Asp Phe Leu Asn Tyr Arg Leu Phe Leu Thr Gly Trp Asp Ser Asn Ile
 465 470 475 480
 Ala Gly His Ala Ala Leu Asn Phe Asp Arg Ala Thr Asp Val Leu Thr
 485 490 495
 Gly Leu Lys Gln Lys Thr Ser Phe Gly Arg Pro Met Trp Asp Asn Glu
 500 505 510
 Phe Ser Arg Ile Ala Thr Ala His Pro Lys Ser Val Val Gly Val Phe
 515 520 525
 Leu Cys Gly Pro Pro Thr Leu Ala Lys Ser Leu Arg Lys Cys Cys Arg
 530 535 540
 Arg Tyr Ser Ser Leu Asp Pro Arg Lys Val Gln Phe Tyr Phe Asn Lys
 545 550 555 560
 Glu Thr Phe

<210> 22
 <211> 2577
 <212> DNA
 <213> Rat

<400> 22
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 cctatcctga aggatcccat cagagaaacc agattgctcc taagaggctc cagacctcca 120
 tttgacaatg ggaaactggc tgggtaacca ctggctctca gttttgtttc tggtttcttg 180
 gttggggctg aacatttttc tgtttgtgta cgtcttcctg aattatgaga agtctgacaa 240
 gtactattac acgagagaaa ttctcggaac tgccttgaggc ttggccagag catctgcttt 300
 gtgcctgaat ttttaacagca tggtgatcct gattcctgtg tgcgaaatc tgctctcctt 360

cctgaggggc acctgctcat ttgcaacca cacgctgaga aagccattgg atcacaacct 420
caccttccat aagctggtgg catatatgat ctgcatattc acagctattc atatcattgc 480
acatctatatt aactttgaac gctacagtag aagccaacag gccatggatg gatctcttgc 540
ctctgtttctc tccagcctat tccatcccga gaaagaagat tcttggctaa atcccatcca 600
gtctccaaac gtgacagtga tgtatgcagc atttaccagt attgctggcc ttactggagt 660
ggtcgccact gtggcttttg ttctcatggt aacttcagct atggagtta tccgcaggaa 720
ttattttgag ctcttctggt atacacatca ctttttcac atctatatca tctgcttagg 780
gatccatggc ctggggggga ttgtccgggg tcaaacagaa gagagcatga gtgaaagtca 840
tccccgcaac tgttcatact ctttcacga gtgggataag tatgaaagga gttgcaggag 900
tcctcatttt gtggggcaac cccctgagtc ttggaagtgg atcctcgccg cgattgcttt 960
ttatatcttt gaaaggatcc ttcgctttta tcgctcccgg cagaaggctg tgattaccaa 1020
ggttgatcatg caccatgta aagttttgga attgcagatg aggaagcggg gctttactat 1080
gggaatagga cagtatatat tcgtaaattg cccctcgatt tccttctctg aatggcatcc 1140
ctttactctg acctctgctc cagaggaaga atttttctcc attcatattc gagcagcagg 1200
ggactggaca gaaaatctca taaggacatt tgaacaacag cactcaccaa tgcccaggat 1260
cgagggtggat ggtccctttg gcacagtcag tgaggatgtc ttccagtacg aagtggctgt 1320
actggttggg gcagggattg gcgtcactcc ctttgcttcc ttcttgaaat ctatctggta 1380
caaattccag cgtgcacaca acaagctgaa aacacaaaag atctatttct actggatttg 1440
tagagagacg ggtgcctttg cctggttcaa caacttattg aattccctgg aacaagagat 1500
ggacgaatta ggcaaaccg atttcctaaa ctaccgactc ttcctcactg gctgggatag 1560
caacattgct ggtcatgcag cattaaactt tgacagagcc actgacgtcc tgacaggtct 1620
gaaacagaaa acctcctttg ggagaccaat gtgggacaat gagttttcta gaatagctac 1680
tgcccacccc aagtctgtgg tgggggtttt cttatgcggc cctccgactt tggcaaaaag 1740
cctgcgcaaa tgctgtcggc ggtactcaag tctggatcct aggaagggtc aattctactt 1800

caacaaagaa acgttctgaa ttggaggaag cgcacagta gtacttctcc atcttctttt 1860
 tctaactcgt gtgggtcagc tactagatag tccgttgctg cacaaggact tcaactcccat 1920
 cttaaagttg actcaactcc atcattcttg ggctttggca acatgagagc tgcataaactc 1980
 acaattgcaa aacacatgaa ttattatttg ggggattgta aatccttctg ggaaacctgc 2040
 ctttagctga atcttgctgg ttgacacttg cacaatttaa cctcaggtgt cttggttgat 2100
 acctgataat ctccctccc acctgtccct cacagaagat ttctaagtag ggtgatttta 2160
 aaatatttat tgaatccagc acaaaacaat aatcataaat aataaacata aaattaccaa 2220
 gattcccaact cccatatcat acccactaag aacatcgta tacatgagct tatcatccag 2280
 tgtgaccaac aatttatact ttactgtgcc aaaataatct tcatctttgc ttattgaaca 2340
 attttgctga ctttccctag taatatctta agtatattaa ctggaatcaa atttgtatta 2400
 tagttagaag ccaactatat tgccagtttg tattgtttga aataactgga aaggcctgac 2460
 ctacatcgtg gggttaattta acagaagctc tttccatttt ttgttggtgt tgtaaagag 2520
 ttttgtttat gaatgtgta taaaaagaaa ataaaaagtt ataattttga cggaataa 2577

<210> 23

<211> 332

<212> PRT

<213> Homo sapiens

<400> 23

| | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Glu | Ser | Met | Asn | Glu | Ser | His | Pro | Arg | Lys | Cys | Ala | Glu | Ser | Phe | Glu |
| 1 | | | | 5 | | | | | 10 | | | | | 15 | |
| Met | Trp | Asp | Asp | Arg | Asp | Ser | His | Cys | Arg | Arg | Pro | Lys | Phe | Glu | Gly |
| | | 20 | | | | | | 25 | | | | | 30 | | |
| His | Pro | Pro | Glu | Ser | Trp | Lys | Trp | Ile | Leu | Ala | Pro | Val | Ile | Leu | Tyr |
| | | 35 | | | | | 40 | | | | | 45 | | | |
| Ile | Cys | Glu | Arg | Ile | Leu | Arg | Phe | Tyr | Arg | Ser | Gln | Gln | Lys | Val | Val |
| | 50 | | | | | 55 | | | | | 60 | | | | |
| Ile | Thr | Lys | Val | Val | Met | His | Pro | Ser | Lys | Val | Leu | Glu | Leu | Gln | Met |
| 65 | | | | | 70 | | | | | 75 | | | | 80 | |

Asn Lys Arg Gly Phe Ser Met Glu Val Gly Gln Tyr Ile Phe Val Asn
 85 90 95
 Cys Pro Ser Ile Ser Leu Leu Glu Trp His Pro Phe Thr Leu Thr Ser
 100 105 110
 Ala Pro Glu Glu Asp Phe Phe Ser Ile His Ile Arg Ala Ala Gly Asp
 115 120 125
 Trp Thr Glu Asn Leu Ile Arg Ala Phe Glu Gln Gln Tyr Ser Pro Ile
 130 135 140
 Pro Arg Ile Glu Val Asp Gly Pro Phe Gly Thr Ala Ser Glu Asp Val
 145 150 155 160
 Phe Gln Tyr Glu Val Ala Val Leu Val Gly Ala Gly Ile Gly Val Thr
 165 170 175
 Pro Phe Ala Ser Ile Leu Lys Ser Ile Trp Tyr Lys Phe Gln Cys Ala
 180 185 190
 Asp His Asn Leu Lys Thr Lys Lys Ile Tyr Phe Tyr Trp Ile Cys Arg
 195 200 205
 Glu Thr Gly Ala Phe Ser Trp Phe Asn Asn Leu Leu Thr Ser Leu Glu
 210 215 220
 Gln Glu Met Glu Glu Leu Gly Lys Val Gly Phe Leu Asn Tyr Arg Leu
 225 230 235 240
 Phe Leu Thr Gly Trp Asp Ser Asn Ile Val Gly His Ala Ala Leu Asn
 245 250 255
 Phe Asp Lys Ala Thr Asp Ile Val Thr Gly Leu Lys Gln Lys Thr Ser
 260 265 270
 Phe Gly Arg Pro Met Trp Asp Asn Glu Phe Ser Thr Ile Ala Thr Ser
 275 280 285
 His Pro Lys Ser Val Val Gly Val Phe Leu Cys Gly Pro Arg Thr Leu
 290 295 300
 Ala Lys Ser Leu Arg Lys Cys Cys His Arg Tyr Ser Ser Leu Asp Pro
 305 310 315 320
 Arg Lys Val Gln Phe Tyr Phe Asn Lys Glu Asn Phe
 325 330

<210> 24
<211> 14
<212> PRT
<213> Homo sapiens

<400> 24
Cys Ala Glu Ser Phe Glu Met Trp Asp Asp Arg Asp Ser His
1 5 10

<210> 25
<211> 14
<212> PRT
<213> Homo sapiens

<400> 25
Lys Ser Leu Arg Lys Cys Cys His Arg Tyr Ser Ser Leu Asp
1 5 10

<210> 26
<211> 24
<212> DNA
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: primer

<400> 26
gaagtgggtgg gaggcgaaga cata 24

<210> 27
<211> 24
<212> DNA
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: primer

<400> 27
cctgtcatac ctgggacggt ctgg 24

<210> 28
<211> 24
<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 28

gagcacagtg agatgcctgt tcag

24

<210> 29

<211> 24

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 29

ggaaggcagc agagagcaat gatg

24

<210> 30

<211> 24

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 30

acatctgcga gcggcacttc caga

24

<210> 31

<211> 25

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 31

agctcgtcaa caggcaggac cgagc

25

<210> 32

<211> 24

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 32

gcagtgcac cacaatcttca gcac

24

<210> 33

<211> 25

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 33

gagagctctg gagacacttg agttc

25

<210> 34

<211> 22

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 34

catgttctct ctggctgaca ag

22

<210> 35

<211> 25

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 35

cacaatagcg agctccgctt cacgc

25

<210> 36

<211> 24

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: primer

<400> 36

gcaggacatc aacctgcac tctc

24

<210> 37

<211> 570

<212> PRT

<213> Bovine

<400> 37

Met Gly Asn Trp Val Val Asn Glu Gly Ile Ser Ile Phe Val Ile Leu
1 5 10 15

Val Trp Leu Gly Met Asn Val Phe Leu Phe Val Trp Tyr Tyr Arg Val
20 25 30

Tyr Asp Ile Pro Asp Lys Phe Phe Tyr Thr Arg Lys Leu Leu Gly Ser
35 40 45

Ala Leu Ala Leu Ala Arg Ala Pro Ala Ala Cys Leu Asn Phe Asn Cys
50 55 60

Met Leu Ile Leu Leu Pro Val Cys Arg Asn Leu Leu Ser Phe Leu Arg
65 70 75 80

Gly Ser Ser Ala Cys Cys Ser Thr Arg Ile Arg Arg Gln Leu Asp Arg
85 90 95

Asn Leu Thr Phe His Lys Met Val Ala Trp Met Ile Ala Leu His Thr
100 105 110

Ala Ile His Thr Ile Ala His Leu Phe Asn Val Glu Trp Cys Val Asn
115 120 125

Ala Arg Val Asn Asn Ser Asp Pro Tyr Ser Ile Ala Leu Ser Asp Ile
130 135 140

Gly Asp Lys Pro Asn Glu Thr Tyr Leu Asn Phe Val Arg Gln Arg Ile
145 150 155 160

Lys Asn Pro Glu Gly Gly Leu Tyr Val Ala Val Thr Arg Leu Ala Gly
165 170 175

Ile Thr Gly Val Val Ile Thr Leu Cys Leu Ile Leu Ile Ile Thr Ser
 180 185 190
 Ser Thr Lys Thr Ile Arg Arg Ser Tyr Phe Glu Val Phe Trp Tyr Thr
 195 200 205
 His His Leu Phe Val Ile Phe Phe Ile Gly Leu Ala Ile His Gly Ala
 210 215 220
 Gln Arg Ile Val Arg Gly Gln Thr Ala Glu Ser Leu Leu Lys His Gln
 225 230 235 240
 Pro Arg Asn Cys Tyr Gln Asn Ile Ser Gln Trp Gly Lys Ile Glu Asn
 245 250 255
 Cys Pro Ile Pro Glu Phe Ser Gly Asn Pro Pro Met Thr Trp Lys Trp
 260 265 270
 Ile Val Gly Pro Met Phe Leu Tyr Leu Cys Glu Arg Leu Val Arg Phe
 275 280 285
 Trp Arg Ser Gln Gln Lys Val Val Ile Thr Lys Val Val Thr His Pro
 290 295 300
 Phe Lys Thr Ile Glu Leu Gln Met Lys Lys Lys Gly Phe Lys Met Glu
 305 310 315 320
 Val Gly Gln Tyr Ile Phe Val Lys Cys Pro Val Val Ser Lys Leu Glu
 325 330 335
 Trp His Pro Phe Thr Leu Thr Ser Ala Pro Glu Glu Asp Phe Phe Ser
 340 345 350
 Ile His Ile Arg Ile Val Gly Asp Trp Thr Glu Gly Leu Phe Lys Ala
 355 360 365
 Cys Gly Cys Asp Lys Gln Glu Phe Gln Asp Ala Trp Lys Leu Pro Lys
 370 375 380
 Ile Ala Val Asp Gly Pro Phe Gly Thr Ala Ser Glu Asp Val Phe Ser
 385 390 395 400
 Tyr Glu Val Val Met Leu Val Gly Ala Gly Ile Gly Val Thr Pro Phe
 405 410 415
 Ala Ser Ile Leu Lys Ser Val Trp Tyr Lys Tyr Cys Asn Lys Ala Pro
 420 425 430

Asn Leu Arg Leu Lys Lys Ile Tyr Phe Tyr Trp Leu Cys Arg Asp Thr
 435 440 445

His Ala Phe Glu Trp Phe Ala Asp Leu Leu Gln Leu Leu Glu Thr Gln
 450 455 460

Met Gln Glu Lys Asn Asn Thr Asp Phe Leu Ser Tyr Asn Ile Cys Leu
 465 470 475 480

Thr Gly Trp Asp Glu Ser Gln Ala Ser His Phe Ala Met His His Asp
 485 490 495

Glu Glu Lys Asp Val Ile Thr Gly Leu Lys Gln Lys Thr Leu Tyr Gly
 500 505 510

Arg Pro Asn Trp Asp Asn Glu Phe Lys Thr Ile Gly Ser Gln His Pro
 515 520 525

Asn Thr Arg Ile Gly Val Phe Leu Cys Gly Pro Glu Ala Leu Ala Asp
 530 535 540

Thr Leu Asn Lys Gln Cys Ile Ser Asn Ser Asp Ser Gly Pro Arg Gly
 545 550 555 560

Val His Phe Ile Phe Asn Lys Glu Asn Phe
 565 570

<210> 38

<211> 570

<212> PRT

<213> murine

<400> 38

Met Gly Asn Trp Ala Val Asn Glu Gly Leu Ser Ile Phe Val Ile Leu
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Val Trp Leu Gly Leu Asn Val Phe Leu Phe Ile Asn Tyr Tyr Lys Val
 20 25 30

Tyr Asp Asp Gly Pro Lys Tyr Asn Tyr Thr Arg Lys Leu Leu Gly Ser
 35 40 45

Ala Leu Ala Leu Ala Arg Ala Pro Ala Ala Cys Leu Asn Phe Asn Cys
 50 55 60

Met Leu Ile Leu Leu Pro Val Cys Arg Asn Leu Leu Ser Phe Leu Arg
 65 70 75 80

Gly Ser Ser Ala Cys Cys Ser Thr Arg Ile Arg Arg Gln Leu Asp Arg
 85 90 95
 Asn Leu Thr Phe His Lys Met Val Ala Trp Met Ile Ala Leu His Thr
 100 105 110
 Ala Ile His Thr Ile Ala His Leu Phe Asn Val Glu Trp Cys Val Asn
 115 120 125
 Ala Arg Val Gly Ile Ser Asp Arg Tyr Ser Ile Ala Leu Ser Asp Ile
 130 135 140
 Gly Asp Asn Glu Asn Glu Glu Tyr Leu Asn Phe Ala Arg Glu Lys Ile
 145 150 155 160
 Lys Asn Pro Glu Gly Gly Leu Tyr Val Ala Val Thr Arg Leu Ala Gly
 165 170 175
 Ile Thr Gly Ile Val Ile Thr Leu Cys Leu Ile Leu Ile Ile Thr Ser
 180 185 190
 Ser Thr Lys Thr Ile Arg Arg Ser Tyr Phe Glu Val Phe Trp Tyr Thr
 195 200 205
 His His Leu Phe Val Ile Phe Phe Ile Gly Leu Ala Ile His Gly Ala
 210 215 220
 Glu Arg Ile Val Arg Gly Gln Thr Ala Glu Ser Leu Glu Glu His Asn
 225 230 235 240
 Leu Asp Ile Cys Ala Asp Lys Ile Glu Glu Trp Gly Lys Ile Lys Glu
 245 250 255
 Cys Pro Val Pro Lys Phe Ala Gly Asn Pro Pro Met Thr Trp Lys Trp
 260 265 270
 Ile Val Gly Pro Met Phe Leu Tyr Leu Cys Glu Arg Leu Val Arg Phe
 275 280 285
 Trp Arg Ser Gln Gln Lys Val Val Ile Thr Lys Val Val Thr His Pro
 290 295 300
 Phe Lys Thr Ile Glu Leu Gln Met Lys Lys Lys Gly Phe Lys Met Glu
 305 310 315 320
 Val Gly Gln Tyr Ile Phe Val Lys Cys Pro Lys Val Ser Lys Leu Glu
 325 330 335

Trp His Pro Phe Thr Leu Thr Ser Ala Pro Glu Glu Asp Phe Phe Ser
 340 345 350
 Ile His Ile Arg Ile Val Gly Asp Trp Thr Glu Gly Leu Phe Asn Ala
 355 360 365
 Cys Gly Cys Asp Lys Gln Glu Phe Gln Asp Ala Trp Lys Leu Pro Lys
 370 375 380
 Ile Ala Val Asp Gly Pro Phe Gly Thr Ala Ser Glu Asp Val Phe Ser
 385 390 395 400
 Tyr Glu Val Val Met Leu Val Gly Ala Gly Ile Gly Val Thr Pro Phe
 405 410 415
 Ala Ser Ile Leu Lys Ser Val Trp Tyr Lys Tyr Cys Asp Asn Ala Thr
 420 425 430
 Ser Leu Lys Leu Lys Lys Ile Tyr Phe Tyr Trp Leu Cys Arg Asp Thr
 435 440 445
 His Ala Phe Glu Trp Phe Ala Asp Leu Leu Gln Leu Leu Glu Thr Gln
 450 455 460
 Met Gln Glu Arg Asn Asn Ala Asn Phe Leu Ser Tyr Asn Ile Tyr Leu
 465 470 475 480
 Thr Gly Trp Asp Glu Ser Gln Ala Asn His Phe Ala Val His His Asp
 485 490 495
 Glu Glu Lys Asp Val Ile Thr Gly Leu Lys Gln Lys Thr Leu Tyr Gly
 500 505 510
 Arg Pro Asn Trp Asp Asn Glu Phe Lys Thr Ile Ala Ser Glu His Pro
 515 520 525
 Asn Thr Thr Ile Gly Val Phe Leu Cys Gly Pro Glu Ala Leu Ala Glu
 530 535 540
 Thr Leu Ser Lys Gln Ser Ile Ser Asn Ser Glu Ser Gly Pro Arg Gly
 545 550 555 560
 Val His Phe Ile Phe Asn Lys Glu Asn Phe
 565 570

<210> 39

<211> 944

<212> PRT

<213> Arabidopsis sp.

<400> 39

Met Lys Pro Phe Ser Lys Asn Asp Arg Arg Arg Trp Ser Phe Asp Ser
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Val Ser Ala Gly Lys Thr Ala Val Gly Ser Ala Ser Thr Ser Pro Gly
 20 25 30

Thr Glu Tyr Ser Ile Asn Gly Asp Gln Glu Phe Val Glu Val Thr Ile
 35 40 45

Asp Leu Gln Asp Asp Asp Thr Ile Val Leu Arg Ser Val Glu Pro Ala
 50 55 60

Thr Ala Ile Asn Val Ile Gly Asp Ile Ser Asp Asp Asn Thr Gly Ile
 65 70 75 80

Met Thr Pro Val Ser Ile Ser Arg Ser Pro Thr Met Lys Arg Thr Ser
 85 90 95

Ser Asn Arg Phe Arg Gln Phe Ser Gln Glu Leu Lys Ala Glu Ala Val
 100 105 110

Ala Lys Ala Lys Gln Leu Ser Gln Glu Leu Lys Arg Phe Ser Trp Ser
 115 120 125

Arg Ser Phe Ser Gly Asn Leu Thr Thr Thr Ser Thr Ala Ala Asn Gln
 130 135 140

Ser Gly Gly Ala Gly Gly Gly Leu Val Asn Ser Ala Leu Glu Ala Arg
 145 150 155 160

Ala Leu Arg Lys Gln Arg Ala Gln Leu Asp Arg Thr Arg Ser Ser Ala
 165 170 175

Gln Arg Ala Leu Arg Gly Leu Arg Phe Ile Ser Asn Lys Gln Lys Asn
 180 185 190

Val Asp Gly Trp Asn Asp Val Gln Ser Asn Phe Glu Lys Phe Glu Lys
 195 200 205

Asn Gly Tyr Ile Tyr Arg Ser Asp Phe Ala Gln Cys Ile Gly Met Lys
 210 215 220

Asp Ser Lys Glu Phe Ala Leu Glu Leu Phe Asp Ala Leu Ser Arg Arg

| | | | |
|---|-----|-----|-----|
| 225 | 230 | 235 | 240 |
| Arg Arg Leu Lys Val Glu Lys Ile Asn His Asp Glu Leu Tyr Glu Tyr | 245 | 250 | 255 |
| Trp Ser Gln Ile Asn Asp Glu Ser Phe Asp Ser Arg Leu Gln Ile Phe | 260 | 265 | 270 |
| Phe Asp Ile Val Asp Lys Asn Glu Asp Gly Arg Ile Thr Glu Glu Glu | 275 | 280 | 285 |
| Val Lys Glu Ile Ile Met Leu Ser Ala Ser Ala Asn Lys Leu Ser Arg | 290 | 295 | 300 |
| Leu Lys Glu Gln Ala Glu Glu Tyr Ala Ala Leu Ile Met Glu Glu Leu | 305 | 310 | 315 |
| Asp Pro Glu Arg Leu Gly Tyr Ile Glu Leu Trp Gln Leu Glu Thr Leu | 325 | 330 | 335 |
| Leu Leu Gln Lys Asp Thr Tyr Leu Asn Tyr Ser Gln Ala Leu Ser Tyr | 340 | 345 | 350 |
| Thr Ser Gln Ala Leu Ser Gln Asn Leu Gln Gly Leu Arg Gly Lys Ser | 355 | 360 | 365 |
| Arg Ile His Arg Met Ser Ser Asp Phe Val Tyr Ile Met Gln Glu Asn | 370 | 375 | 380 |
| Trp Lys Arg Ile Trp Val Leu Ser Leu Trp Ile Met Ile Met Ile Gly | 385 | 390 | 395 |
| Leu Phe Leu Trp Lys Phe Phe Gln Tyr Lys Gln Lys Asp Ala Phe His | 405 | 410 | 415 |
| Val Met Gly Tyr Cys Leu Leu Thr Ala Lys Gly Ala Ala Glu Thr Leu | 420 | 425 | 430 |
| Lys Phe Asn Met Ala Leu Ile Leu Phe Pro Val Cys Arg Asn Thr Ile | 435 | 440 | 445 |
| Thr Trp Leu Arg Ser Thr Arg Leu Ser Tyr Phe Val Pro Phe Asp Asp | 450 | 455 | 460 |
| Asn Ile Asn Phe His Lys Thr Ile Ala Gly Ala Ile Val Val Ala Val | 465 | 470 | 475 |
| Ile Leu His Ile Gly Asp His Leu Ala Cys Asp Phe Pro Arg Ile Val | | | 480 |

| 485 | | | | | | | | | | 490 | | | | | | | | | | 495 | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|--|--|--|-----|--|--|--|--|--|--|--|--|--|-----|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| Arg | Ala | Thr | Glu | Tyr | Asp | Tyr | Asn | Arg | Tyr | Leu | Phe | His | Tyr | Phe | Gln | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 500 | | | | | | | | | | 505 | | | | | | | | | | 510 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Thr | Lys | Gln | Pro | Thr | Tyr | Phe | Asp | Leu | Val | Lys | Gly | Pro | Glu | Gly | Ile | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 515 | | | | | | | | | | 520 | | | | | | | | | | 525 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Thr | Gly | Ile | Leu | Met | Val | Ile | Leu | Met | Ile | Ile | Ser | Phe | Thr | Leu | Ala | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 530 | | | | | | | | | | 535 | | | | | | | | | | 540 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Thr | Arg | Trp | Phe | Arg | Arg | Asn | Leu | Val | Lys | Leu | Pro | Lys | Pro | Phe | Asp | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 545 | | | | | | | | | | 550 | | | | | | | | | | 555 | | | | | | | | | | 560 | | | | | | | | | | | | | | | |
| Arg | Leu | Thr | Gly | Phe | Asn | Ala | Phe | Trp | Tyr | Ser | His | His | Leu | Phe | Val | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 565 | | | | | | | | | | 570 | | | | | | | | | | 575 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ile | Val | Tyr | Ile | Leu | Leu | Ile | Leu | His | Gly | Ile | Phe | Leu | Tyr | Phe | Ala | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 580 | | | | | | | | | | 585 | | | | | | | | | | 590 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lys | Pro | Trp | Tyr | Val | Arg | Thr | Thr | Trp | Met | Tyr | Leu | Ala | Val | Pro | Val | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 595 | | | | | | | | | | 600 | | | | | | | | | | 605 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Leu | Leu | Tyr | Gly | Gly | Glu | Arg | Thr | Leu | Arg | Tyr | Phe | Arg | Ser | Gly | Ser | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 610 | | | | | | | | | | 615 | | | | | | | | | | 620 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tyr | Ser | Val | Arg | Leu | Leu | Lys | Val | Ala | Ile | Tyr | Pro | Gly | Asn | Val | Leu | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 625 | | | | | | | | | | 630 | | | | | | | | | | 635 | | | | | | | | | | 640 | | | | | | | | | | | | | | | |
| Thr | Leu | Gln | Met | Ser | Lys | Pro | Thr | Gln | Phe | Arg | Tyr | Lys | Ser | Gly | Gln | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 645 | | | | | | | | | | 650 | | | | | | | | | | 655 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tyr | Met | Phe | Val | Gln | Cys | Pro | Ala | Val | Ser | Pro | Phe | Glu | Trp | His | Pro | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 660 | | | | | | | | | | 665 | | | | | | | | | | 670 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Phe | Ser | Ile | Thr | Ser | Ala | Pro | Glu | Asp | Asp | Tyr | Ile | Ser | Ile | His | Ile | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 675 | | | | | | | | | | 680 | | | | | | | | | | 685 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Arg | Gln | Leu | Gly | Asp | Trp | Thr | Gln | Glu | Leu | Lys | Arg | Val | Phe | Ser | Glu | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 690 | | | | | | | | | | 695 | | | | | | | | | | 700 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Val | Cys | Glu | Pro | Pro | Val | Gly | Gly | Lys | Ser | Gly | Leu | Leu | Arg | Ala | Asp | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 705 | | | | | | | | | | 710 | | | | | | | | | | 715 | | | | | | | | | | 720 | | | | | | | | | | | | | | | |
| Glu | Thr | Thr | Lys | Lys | Ser | Leu | Pro | Lys | Leu | Leu | Ile | Asp | Gly | Pro | Tyr | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 725 | | | | | | | | | | 730 | | | | | | | | | | 735 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Gly | Ala | Pro | Ala | Gln | Asp | Tyr | Arg | Lys | Tyr | Asp | Val | Leu | Leu | Leu | Val | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | |
|---|-----|-----|
| 740 | 745 | 750 |
| Gly Leu Gly Ile Gly Ala Thr Pro Phe Ile Ser Ile Leu Lys Asp Leu | | |
| 755 | 760 | 765 |
| Leu Asn Asn Ile Val Lys Met Glu Glu His Ala Asp Ser Ile Ser Asp | | |
| 770 | 775 | 780 |
| Phe Ser Arg Ser Ser Glu Tyr Ser Thr Gly Ser Asn Gly Asp Thr Pro | | |
| 785 | 790 | 795 |
| | | 800 |
| Arg Arg Lys Arg Ile Leu Lys Thr Thr Asn Ala Tyr Phe Tyr Trp Val | | |
| 805 | 810 | 815 |
| Thr Arg Glu Gln Gly Ser Phe Asp Trp Phe Lys Gly Val Met Asn Glu | | |
| 820 | 825 | 830 |
| Val Ala Glu Leu Asp Gln Arg Gly Val Ile Glu Met His Asn Tyr Leu | | |
| 835 | 840 | 845 |
| Thr Ser Val Tyr Glu Glu Gly Asp Ala Arg Ser Ala Leu Ile Thr Met | | |
| 850 | 855 | 860 |
| Val Gln Ala Leu Asn His Ala Lys Asn Gly Val Asp Ile Val Ser Gly | | |
| 865 | 870 | 875 |
| | | 880 |
| Thr Arg Val Arg Thr His Phe Ala Arg Pro Asn Trp Lys Lys Val Leu | | |
| 885 | 890 | 895 |
| Thr Lys Leu Ser Ser Lys His Cys Asn Ala Arg Ile Gly Val Phe Tyr | | |
| 900 | 905 | 910 |
| Cys Gly Val Pro Val Leu Gly Lys Glu Leu Ser Lys Leu Cys Asn Thr | | |
| 915 | 920 | 925 |
| Phe Asn Gln Lys Gly Ser Thr Lys Phe Glu Phe His Lys Glu His Phe | | |
| 930 | 935 | 940 |

<210> 40

<211> 590

<212> PRT

<213> Rice

<400> 40

Asn Leu Ala Gly Leu Arg Lys Lys Ser Ser Ile Arg Lys Ile Ser Thr
 1 5 10 15
 Ser Leu Ser Tyr Tyr Phe Glu Asp Asn Trp Lys Arg Leu Trp Val Leu
 20 25 30
 Ala Leu Trp Ile Gly Ile Met Ala Gly Leu Phe Thr Trp Lys Phe Met
 35 40 45
 Gln Tyr Arg Asn Arg Tyr Val Phe Asp Val Met Gly Tyr Cys Val Thr
 50 55 60
 Thr Ala Lys Gly Ala Ala Glu Thr Leu Lys Leu Asn Met Ala Ile Ile
 65 70 75 80
 Leu Leu Pro Val Cys Arg Asn Thr Ile Thr Trp Leu Arg Ser Thr Arg
 85 90 95
 Ala Ala Arg Ala Leu Pro Phe Asp Asp Asn Ile Asn Phe His Lys Thr
 100 105 110
 Ile Ala Ala Ala Ile Val Val Gly Ile Ile Leu His Ala Gly Asn His
 115 120 125
 Leu Val Cys Asp Phe Pro Arg Leu Ile Lys Ser Ser Asp Glu Lys Tyr
 130 135 140
 Ala Pro Leu Gly Gln Tyr Phe Gly Glu Ile Lys Pro Thr Tyr Phe Thr
 145 150 155 160
 Leu Val Lys Gly Val Glu Gly Ile Thr Gly Val Ile Met Val Val Cys
 165 170 175
 Met Ile Ile Ala Phe Thr Leu Ala Thr Arg Trp Phe Arg Arg Ser Leu
 180 185 190
 Val Lys Leu Pro Arg Pro Phe Asp Lys Leu Thr Gly Phe Asn Ala Phe
 195 200 205
 Trp Tyr Ser His His Leu Phe Ile Ile Val Tyr Ile Ala Leu Ile Val
 210 215 220
 His Gly Glu Cys Leu Tyr Leu Ile His Val Trp Tyr Arg Arg Thr Thr
 225 230 235 240
 Trp Met Tyr Leu Ser Val Pro Val Cys Leu Tyr Val Gly Glu Arg Ile
 245 250 255

Leu Arg Phe Phe Arg Ser Gly Ser Tyr Ser Val Arg Leu Leu Lys Val
 260 265 270
 Ala Ile Tyr Pro Gly Asn Val Leu Thr Leu Gln Met Ser Lys Pro Pro
 275 280 285
 Thr Phe Arg Tyr Lys Ser Gly Gln Tyr Met Phe Val Gln Cys Pro Ala
 290 295 300
 Val Ser Pro Phe Glu Trp His Pro Phe Ser Ile Thr Ser Ala Pro Gly
 305 310 315 320
 Asp Asp Tyr Leu Ser Ile His Val Arg Gln Leu Gly Asp Trp Thr Arg
 325 330 335
 Glu Leu Lys Arg Val Phe Ala Ala Ala Cys Glu Pro Pro Ala Gly Gly
 340 345 350
 Lys Ser Gly Leu Leu Arg Ala Asp Glu Thr Thr Lys Lys Ile Leu Pro
 355 360 365
 Lys Leu Leu Ile Asp Gly Pro Tyr Gly Ser Pro Ala Gln Asp Tyr Ser
 370 375 380
 Lys Tyr Asp Val Leu Leu Leu Val Gly Leu Gly Ile Gly Ala Thr Pro
 385 390 395 400
 Phe Ile Ser Ile Leu Lys Asp Leu Leu Asn Asn Ile Ile Lys Met Glu
 405 410 415
 Glu Glu Glu Asp Ala Ser Thr Asp Leu Tyr Pro Pro Met Gly Arg Asn
 420 425 430
 Asn Pro His Val Asp Leu Gly Thr Leu Met Thr Ile Thr Ser Arg Pro
 435 440 445
 Lys Lys Ile Leu Lys Thr Thr Asn Ala Tyr Phe Tyr Trp Val Thr Arg
 450 455 460
 Glu Gln Gly Ser Phe Asp Trp Phe Lys Gly Val Met Asn Glu Ile Ala
 465 470 475 480
 Asp Leu Asp Gln Arg Asn Ile Ile Glu Met His Asn Tyr Leu Thr Ser
 485 490 495
 Val Tyr Glu Glu Gly Asp Ala Arg Ser Ala Leu Ile Thr Met Leu Gln
 500 505 510

Ala Leu Asn His Ala Lys Asn Gly Val Asp Ile Val Ser Gly Thr Lys
 515 520 525

Val Arg Thr His Phe Ala Arg Pro Asn Trp Arg Lys Val Leu Ser Lys
 530 535 540

Ile Ser Ser Lys His Pro Tyr Ala Lys Ile Gly Val Phe Tyr Cys Gly
 545 550 555 560

Ala Pro Val Leu Ala Gln Glu Leu Ser Lys Leu Cys His Glu Phe Asn
 565 570 575

Gly Lys Cys Thr Thr Lys Phe Asp Phe His Lys Glu His Phe
 580 585 590

<210> 41

<211> 2619

<212> DNA

<213> Rat

<400> 41

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 acagaagtca tgctaaaatc tctttcatgc atgtcttctt ttttcagtct ctccctttccc 120
 aaagcttttc agtttgcctt ttgcttgtag caactgctat ccctcctcaa aggctgctgc 180
 aaaaggtagt cctttttctt ggaggctttc agcaaatact acctgggaac ctgcttcagc 240
 tcttggaata ttaagtga gagaacattt catagcattt gtatctttct ttgaaggagc 300
 caccagacag actgccttgg ccttgccag agcatctgct ttgtgcctga attttaacag 360
 catggtgatc ctgattcctg tgtgtcgaaa tctgctctcc ttccctgaggg gcacctgctc 420
 attttgcaac cacacgctga gaaagccatt ggatcacaac ctcaccttcc ataagctggt 480
 ggcatatatg atctgcatat tcacagctat tcatatcatt gcacatctat ttaactttga 540
 acgttacagt agaagccaac aggccatgga tggatctctt gcctctgttc tctccagcct 600
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 gatgtatgca gcatttacca gtattgctgg ccttactgga gtggtcgcca ctgtggcttt 720
 ggttctcatg gtaacttcag ctatggagtt tatccgcagg aattattttg agctcttctg 780

gtatacacat caccttttca tcatctatat catctgctta gggatccatg gcctgggggg 840
gattgtccgg ggtcaaacag aagagagcat gagtgaagt catccccgca actgttcata 900
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taaagttttg gaattgcaga tgaggaagcg gggctttact atgggaatag gacagtatat 1140
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tgccacagtc agtgaggatg tcttcagta cgaagtggct gtactgggtg gggcaggat 1380
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ccatcattct tgggcttttg caacatgaga gctgcataac tcacaattgc aaaacacatg 2040
aattattatt ggggggattg taaatccttc tgggaaacct gccttttagct gaatcttgct 2100
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cgacaaaaca ataatcataa ataataaaca taaaattacc aagattccca ctcccatatc 2280
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 agtaatatct taagtatatt aactggaatc aaatttgtat tatagttaga agccaactat 2460
 attgccagtt tgtattgttt gaaataactg gaaaggcctg acctacatcg tggggtaatt 2520
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<210> 42

<211> 499

<212> PRT

<213> Rat

<400> 42

Met Val Ile Leu Ile Pro Val Cys Arg Asn Leu Leu Ser Phe Leu Arg
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Gly Thr Cys Ser Phe Cys Asn His Thr Leu Arg Lys Pro Leu Asp His
 20 25 30

Asn Leu Thr Phe His Lys Leu Val Ala Tyr Met Ile Cys Ile Phe Thr
 35 40 45

Ala Ile His Ile Ile Ala His Leu Phe Asn Phe Glu Arg Tyr Ser Arg
 50 55 60

Ser Gln Gln Ala Met Asp Gly Ser Leu Ala Ser Val Leu Ser Ser Leu
 65 70 75 80

Phe His Pro Glu Lys Glu Asp Ser Trp Leu Asn Pro Ile Gln Ser Pro
 85 90 95

Asn Val Thr Val Met Tyr Ala Ala Phe Thr Ser Ile Ala Gly Leu Thr
 100 105 110

Gly Val Val Ala Thr Val Ala Leu Val Leu Met Val Thr Ser Ala Met
 115 120 125

Glu Phe Ile Arg Arg Asn Tyr Phe Glu Leu Phe Trp Tyr Thr His His
 130 135 140

Leu Phe Ile Ile Tyr Ile Ile Cys Leu Gly Ile His Gly Leu Gly Gly
 145 150 155 160
 Ile Val Arg Gly Gln Thr Glu Glu Ser Met Ser Glu Ser His Pro Arg
 165 170 175
 Asn Cys Ser Tyr Ser Phe His Glu Trp Asp Lys Tyr Glu Arg Ser Cys
 180 185 190
 Arg Ser Pro His Phe Val Gly Gln Pro Pro Glu Ser Trp Lys Trp Ile
 195 200 205
 Leu Ala Pro Ile Ala Phe Tyr Ile Phe Glu Arg Ile Leu Arg Phe Tyr
 210 215 220
 Arg Ser Arg Gln Lys Val Val Ile Thr Lys Val Val Met His Pro Cys
 225 230 235 240
 Lys Val Leu Glu Leu Gln Met Arg Lys Arg Gly Phe Thr Met Gly Ile
 245 250 255
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 His Pro Phe Thr Leu Thr Ser Ala Pro Glu Glu Glu Phe Phe Ser Ile
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 His Ile Arg Ala Ala Gly Asp Trp Thr Glu Asn Leu Ile Arg Thr Phe
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 Glu Gln Gln His Ser Pro Met Pro Arg Ile Glu Val Asp Gly Pro Phe
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 Gly Thr Val Ser Glu Asp Val Phe Gln Tyr Glu Val Ala Val Leu Val
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 Trp Tyr Lys Phe Gln Arg Ala His Asn Lys Leu Lys Thr Gln Lys Ile
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 Tyr Phe Tyr Trp Ile Cys Arg Glu Thr Gly Ala Phe Ala Trp Phe Asn
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Asp Phe Leu Asn Tyr Arg Leu Phe Leu Thr Gly Trp Asp Ser Asn Ile
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Gly Leu Lys Gln Lys Thr Ser Phe Gly Arg Pro Met Trp Asp Asn Glu
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Phe Ser Arg Ile Ala Thr Ala His Pro Lys Ser Val Val Gly Val Phe
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 241 REPFLQALGL LWFYHNLWA QRLARQHPDW EDEELFQHAR KRVIATYQNI AVYEWLPSFL
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 421 ASCLQRGRDL GLPSYTKARA ALGLSPITRW QDINPALSRS NDTVLEATAA LYNQDLWL
 481 LLPGGLES LRDGGLFSTI VLEQFVRLRD GDRYWFENTR NGLFSKKEIE EIRNTTLQDV
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| Leu Asp Glu Asn Gly Phe Leu Ser Lys Asp Glu Phe Phe Thr Met Met | |
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| Arg Ser Phe Ile Glu Ile Ser Asn Asn Cys Leu Ser Lys Ala Gln Leu | |
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| gcc gag gtg gtg gag tct atg ttc cgg gag tgc gga ttc cag gac aag | 1238 |
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| Glu Glu Leu Thr Trp Glu Asp Phe His Phe Met Leu Arg Asp His Asp | |
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| Lys | Arg | Phe | Gly | Lys | Lys | Ala | Ala | Val | Pro | Thr | Pro | Arg | Leu | Tyr | Thr | | |
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| gag | gcg | ctg | caa | gag | aag | atg | cag | cga | ggc | ttc | cta | gcc | caa | aag | ctg | 1574 | |
| Glu | Ala | Leu | Gln | Glu | Lys | Met | Gln | Arg | Gly | Phe | Leu | Ala | Gln | Lys | Leu | | |
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| cag | cag | tac | aag | cgc | ttc | gtg | gag | aac | tac | cgg | agg | cac | atc | gtg | tgt | 1622 | |
| Gln | Gln | Tyr | Lys | Arg | Phe | Val | Glu | Asn | Tyr | Arg | Arg | His | Ile | Val | Cys | | |
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| gtg | gca | atc | ttc | tcg | gcc | atc | tgt | gtt | ggc | gtg | ttt | gca | gat | cgt | gct | 1670 | |
| Val | Ala | Ile | Phe | Ser | Ala | Ile | Cys | Val | Gly | Val | Phe | Ala | Asp | Arg | Ala | | |
| | | | | | 400 | | | | 405 | | | | | 410 | | | |
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| Tyr | Tyr | Tyr | Gly | Phe | Ala | Leu | Pro | Pro | Ser | Asp | Ile | Ala | Gln | Thr | Thr | | |
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| Leu | Val | Gly | Ile | Ile | Leu | Ser | Arg | Gly | Thr | Ala | Ala | Ser | Val | Ser | Phe | | |
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| Met | Phe | Ser | Tyr | Ile | Leu | Leu | Thr | Met | Cys | Arg | Asn | Leu | Ile | Thr | Phe | | |
| | | | 445 | | | | 450 | | | | 455 | | | | | | |
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| Leu | Arg | Glu | Thr | Phe | Leu | Asn | Arg | Tyr | Val | Pro | Phe | Asp | Ala | Ala | Val | | |
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| gac | ttc | cac | cgc | tgg | atc | gcc | atg | gct | gct | gtt | gtc | ctg | gcc | att | ttg | 1910 | |

| | |
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| His Ser Ala Gly His Ala Val Asn Val Tyr Ile Phe Ser Val Ser Pro | |
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| Leu Ser Leu Leu Ala Cys Ile Phe Pro Asn Val Phe Val Asn Asp Gly | |
| 510 515 520 | |
| tcc aag ctt ccc cag aag ttc tat tgg tgg ttc ttc cag acc gtc cca | 2054 |
| Ser Lys Leu Pro Gln Lys Phe Tyr Trp Trp Phe Phe Gln Thr Val Pro | |
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| ggt atg aca ggt gtg ctt ctg ctc ctg gtc ctg gcc atc atg tat gtc | 2102 |
| Gly Met Thr Gly Val Leu Leu Leu Leu Val Leu Ala Ile Met Tyr Val | |
| 540 545 550 555 | |
| ttc gcc tcc cac cac ttc cgc cgc cgc agc ttc cgg ggc ttc tgg ctg | 2150 |
| Phe Ala Ser His His Phe Arg Arg Arg Ser Phe Arg Gly Phe Trp Leu | |
| 560 565 570 | |
| acc cac cac ctc tac atc ctg ctc tat gcc ctg ctc atc atc cat ggc | 2198 |
| Thr His His Leu Tyr Ile Leu Leu Tyr Ala Leu Leu Ile Ile His Gly | |
| 575 580 585 | |
| agc tat gct ctg atc cag ctg ccc act ttc cac atc tac ttc ctg gtc | 2246 |
| Ser Tyr Ala Leu Ile Gln Leu Pro Thr Phe His Ile Tyr Phe Leu Val | |
| 590 595 600 | |
| ccg gca atc atc tat gga ggt gac aag ctg gtg agc ctg agc cgg aag | 2294 |
| Pro Ala Ile Ile Tyr Gly Gly Asp Lys Leu Val Ser Leu Ser Arg Lys | |
| 605 610 615 | |
| aag gtg gag atc agc gtg gtg aag gcg gag ctg ctg ccc tca gga gtg | 2342 |
| Lys Val Glu Ile Ser Val Val Lys Ala Glu Leu Leu Pro Ser Gly Val | |
| 620 625 630 635 | |
| acc tac ctg caa ttc cag agg ccc caa ggc ttt gag tac aag tca gga | 2390 |
| Thr Tyr Leu Gln Phe Gln Arg Pro Gln Gly Phe Glu Tyr Lys Ser Gly | |
| 640 645 650 | |
| cag tgg gtg cgg atc gcc tgc ctg gct ctg ggg acc acc gag tac cac | 2438 |
| Gln Trp Val Arg Ile Ala Cys Leu Ala Leu Gly Thr Thr Glu Tyr His | |
| 655 660 665 | |
| ccc ttc aca ctg acc tcc gcg ccc cat gag gac aca ctc agc ctg cac | 2486 |

| | | |
|---|-------------------------------------|-------------|
| Pro Phe Thr Leu Thr Ser Ala | Pro His Glu Asp Thr Leu Ser Leu His | |
| 670 | 675 | 680 |
| atc cgg gca gtg ggg ccc tgg acc act cgc ctc agg gag atc tac tca | | 2534 |
| Ile Arg Ala Val Gly Pro Trp Thr Thr Arg Leu Arg Glu Ile Tyr Ser | | |
| 685 | 690 | 695 |
| tcc cca aag ggc aat ggc tgt gct gga tac cca aag ctg tac ctt gat | | 2582 |
| Ser Pro Lys Gly Asn Gly Cys Ala Gly Tyr Pro Lys Leu Tyr Leu Asp | | |
| 700 | 705 | 710 715 |
| gga ccg ttt gga gag ggc cat cag gag tgg cat aaa ttt gag gtg tca | | 2630 |
| Gly Pro Phe Gly Glu Gly His Gln Glu Trp His Lys Phe Glu Val Ser | | |
| | 720 | 725 730 |
| gtg ttg gtg gga ggg ggc att ggg gtc acc ccc ttt gcc tcc atc ctc | | 2678 |
| Val Leu Val Gly Gly Gly Ile Gly Val Thr Pro Phe Ala Ser Ile Leu | | |
| | 735 | 740 745 |
| aaa gac ctg gtc ttc aag tca tcc ttg ggc agc caa atg ctg tgt aag | | 2726 |
| Lys Asp Leu Val Phe Lys Ser Ser Leu Gly Ser Gln Met Leu Cys Lys | | |
| | 750 | 755 760 |
| aag atc tac ttc atc tgg gtg aca cgg acc cag cgt cag ttt gag tgg | | 2774 |
| Lys Ile Tyr Phe Ile Trp Val Thr Arg Thr Gln Arg Gln Phe Glu Trp | | |
| | 765 | 770 775 |
| ctg gct gac atc atc caa gag gtg gag gag aac gac cac cag gac ctg | | 2822 |
| Leu Ala Asp Ile Ile Gln Glu Val Glu Glu Asn Asp His Gln Asp Leu | | |
| | 780 | 785 790 795 |
| gtg tct gtg cac att tat gtc acc cag ctg gct gag aag ttc gac ctc | | 2870 |
| Val Ser Val His Ile Tyr Val Thr Gln Leu Ala Glu Lys Phe Asp Leu | | |
| | 800 | 805 810 |
| agg acc acc atg cta tac atc tgc gag cgg cac ttc cag aaa gtg ctg | | 2918 |
| Arg Thr Thr Met Leu Tyr Ile Cys Glu Arg His Phe Gln Lys Val Leu | | |
| | 815 | 820 825 |
| aac cgg agt ctg ttc acg ggc ctg cgc tcc atc acc cac ttt ggc cgt | | 2966 |
| Asn Arg Ser Leu Phe Thr Gly Leu Arg Ser Ile Thr His Phe Gly Arg | | |
| | 830 | 835 840 |
| ccc ccc ttc gag ccc ttc ttc aac tcc ctg cag gag gtc cac cca cag | | 3014 |
| Pro Pro Phe Glu Pro Phe Phe Asn Ser Leu Gln Glu Val His Pro Gln | | |
| | 845 | 850 855 |
| gtg cgc aag atc ggg gtg ttc agc tgc ggc cct cca gga atg acc aag | | 3062 |

Val Arg Lys Ile Gly Val Phe Ser Cys Gly Pro Pro Gly Met Thr Lys
 860 865 870 875

aat gta gag aag gcc tgt cag ctc gtc aac agg cag gac cga gcc cac 3110
 Asn Val Glu Lys Ala Cys Gln Leu Val Asn Arg Gln Asp Arg Ala His
 880 885 890

ttc atg cac cac tat gag aac ttc tgagcctgtc ctccctggct gctgcttcca 3164
 Phe Met His His Tyr Glu Asn Phe
 895

gtatcctgcc ttctcttctg tgcacctaag ttgccagccc ctgctggcaa tctctccatc 3224

agaatccacc ttaggcctca gctggagggc tgcagagccc ctcccaatat tgggagaata 3284

ttgaccaga caattataca aatgagaaaa ggcattaaaa tttacgtttc tgatgatggc 3344

aaagctcatt tttctattag taactctgct gaagatccat ttattgcaat tcatgctgaa 3404

tctaaattgt aaaatttaaa attaaatgca tgtcctcaaa aaaaaaaaaa 3453

<210> 48
 <211> 899
 <212> PRT
 <213> Homo sapiens

<400> 48
 Met Glu Trp Pro Gly Pro Lys Glu Arg Ser Ser Pro Ile Ile Ile Gln
 1 5 10 15

Leu Leu Ser Asp Arg Cys Leu Gln Val Leu Asn Arg His Leu Thr Val
 20 25 30

Leu Arg Val Val Gln Leu Gln Pro Leu Gln Gln Val Asn Leu Ile Leu
 35 40 45

Ser Asn Asn Arg Gly Cys Arg Thr Leu Leu Leu Lys Ile Pro Lys Glu
 50 55 60

Tyr Asp Leu Val Leu Leu Phe Ser Ser Glu Glu Glu Arg Gly Ala Phe
 65 70 75 80

Val Gln Gln Leu Trp Asp Phe Cys Val Arg Trp Ala Leu Gly Leu His
 85 90 95

Val Ala Glu Met Ser Glu Lys Glu Leu Phe Arg Lys Ala Val Thr Lys
 100 105 110

Gln Gln Arg Glu Arg Ile Leu Glu Ile Phe Phe Arg His Leu Phe Ala
 115 120 125
 Gln Val Leu Asp Ile Asn Gln Ala Asp Ala Gly Thr Leu Pro Leu Asp
 130 135 140
 Ser Ser Gln Lys Val Arg Glu Ala Leu Thr Cys Glu Leu Ser Arg Ala
 145 150 155 160
 Glu Phe Ala Glu Ser Leu Gly Leu Lys Pro Gln Asp Met Phe Val Glu
 165 170 175
 Ser Met Phe Ser Leu Ala Asp Lys Asp Gly Asn Gly Tyr Leu Ser Phe
 180 185 190
 Arg Glu Phe Leu Asp Ile Leu Val Val Phe Met Lys Gly Ser Pro Glu
 195 200 205
 Asp Lys Ser Arg Leu Met Phe Thr Met Tyr Asp Leu Asp Glu Asn Gly
 210 215 220
 Phe Leu Ser Lys Asp Glu Phe Phe Thr Met Met Arg Ser Phe Ile Glu
 225 230 235 240
 Ile Ser Asn Asn Cys Leu Ser Lys Ala Gln Leu Ala Glu Val Val Glu
 245 250 255
 Ser Met Phe Arg Glu Ser Gly Phe Gln Asp Lys Glu Glu Leu Thr Trp
 260 265 270
 Glu Asp Phe His Phe Met Leu Arg Asp His Asp Ser Glu Leu Arg Phe
 275 280 285
 Thr Gln Leu Cys Val Lys Gly Gly Gly Gly Gly Gly Asn Gly Ile Arg
 290 295 300
 Asp Ile Phe Lys Gln Asn Ile Ser Cys Arg Val Ser Phe Ile Thr Arg
 305 310 315 320
 Thr Pro Gly Glu Arg Ser His Pro Gln Gly Leu Gly Pro Pro Val Pro
 325 330 335
 Glu Ala Pro Glu Leu Gly Gly Pro Gly Leu Lys Lys Arg Phe Gly Lys
 340 345 350
 Lys Ala Ala Val Pro Thr Pro Arg Leu Tyr Thr Glu Ala Leu Gln Glu
 355 360 365

Lys Met Gln Arg Gly Phe Leu Ala Gln Lys Leu Gln Gln Tyr Lys Arg
 370 375 380
 Phe Val Glu Asn Tyr Arg Arg His Ile Val Cys Val Ala Ile Phe Ser
 385 390 395 400
 Ala Ile Cys Val Gly Val Phe Ala Asp Arg Ala Tyr Tyr Tyr Gly Phe
 405 410 415
 Ala Leu Pro Pro Ser Asp Ile Ala Gln Thr Thr Leu Val Gly Ile Ile
 420 425 430
 Leu Ser Arg Gly Thr Ala Ala Ser Val Ser Phe Met Phe Ser Tyr Ile
 435 440 445
 Leu Leu Thr Met Cys Arg Asn Leu Ile Thr Phe Leu Arg Glu Thr Phe
 450 455 460
 Leu Asn Arg Tyr Val Pro Phe Asp Ala Ala Val Asp Phe His Arg Trp
 465 470 475 480
 Ile Ala Met Ala Ala Val Val Leu Ala Ile Leu His Ser Ala Gly His
 485 490 495
 Ala Val Asn Val Tyr Ile Phe Ser Val Ser Pro Leu Ser Leu Leu Ala
 500 505 510
 Cys Ile Phe Pro Asn Val Phe Val Asn Asp Gly Ser Lys Leu Pro Gln
 515 520 525
 Lys Phe Tyr Trp Trp Phe Phe Gln Thr Val Pro Gly Met Thr Gly Val
 530 535 540
 Leu Leu Leu Leu Val Leu Ala Ile Met Tyr Val Phe Ala Ser His His
 545 550 555 560
 Phe Arg Arg Arg Ser Phe Arg Gly Phe Trp Leu Thr His His Leu Tyr
 565 570 575
 Ile Leu Leu Tyr Ala Leu Leu Ile Ile His Gly Ser Tyr Ala Leu Ile
 580 585 590
 Gln Leu Pro Thr Phe His Ile Tyr Phe Leu Val Pro Ala Ile Ile Tyr
 595 600 605
 Gly Gly Asp Lys Leu Val Ser Leu Ser Arg Lys Lys Val Glu Ile Ser
 610 615 620

Val Val Lys Ala Glu Leu Leu Pro Ser Gly Val Thr Tyr Leu Gln Phe
 625 630 635 640
 Gln Arg Pro Gln Gly Phe Glu Tyr Lys Ser Gly Gln Trp Val Arg Ile
 645 650 655
 Ala Cys Leu Ala Leu Gly Thr Thr Glu Tyr His Pro Phe Thr Leu Thr
 660 665 670
 Ser Ala Pro His Glu Asp Thr Leu Ser Leu His Ile Arg Ala Val Gly
 675 680 685
 Pro Trp Thr Thr Arg Leu Arg Glu Ile Tyr Ser Ser Pro Lys Gly Asn
 690 695 700
 Gly Cys Ala Gly Tyr Pro Lys Leu Tyr Leu Asp Gly Pro Phe Gly Glu
 705 710 715 720
 Gly His Gln Glu Trp His Lys Phe Glu Val Ser Val Leu Val Gly Gly
 725 730 735
 Gly Ile Gly Val Thr Pro Phe Ala Ser Ile Leu Lys Asp Leu Val Phe
 740 745 750
 Lys Ser Ser Leu Gly Ser Gln Met Leu Cys Lys Lys Ile Tyr Phe Ile
 755 760 765
 Trp Val Thr Arg Thr Gln Arg Gln Phe Glu Trp Leu Ala Asp Ile Ile
 770 775 780
 Gln Glu Val Glu Glu Asn Asp His Gln Asp Leu Val Ser Val His Ile
 785 790 795 800
 Tyr Val Thr Gln Leu Ala Glu Lys Phe Asp Leu Arg Thr Thr Met Leu
 805 810 815
 Tyr Ile Cys Glu Arg His Phe Gln Lys Val Leu Asn Arg Ser Leu Phe
 820 825 830
 Thr Gly Leu Arg Ser Ile Thr His Phe Gly Arg Pro Pro Phe Glu Pro
 835 840 845
 Phe Phe Asn Ser Leu Gln Glu Val His Pro Gln Val Arg Lys Ile Gly
 850 855 860
 Val Phe Ser Cys Gly Pro Pro Gly Met Thr Lys Asn Val Glu Lys Ala
 865 870 875 880

Cys Gln Leu Val Asn Arg Gln Asp Arg Ala His Phe Met His His Tyr
 885 890 895

Glu Asn Phe

<210> 49
 <211> 26
 <212> DNA
 <213> Artificial Sequence

<220>
 <223> Description of Artificial Sequence: Primer

<400> 49
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<210> 50
 <211> 24
 <212> DNA
 <213> Artificial Sequence

<220>
 <223> Description of Artificial Sequence: Primer

<400> 50
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<210> 51
 <211> 26
 <212> DNA
 <213> Artificial Sequence

<220>
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 ctagaagctc tccttggtgt aataga 26

<210> 52
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 <212> DNA
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<220>

<223> Description of Artificial Sequence: Primer

<400> 52

atgaacacct ctggggtcag ctga

24

<210> 53

<211> 24

<212> DNA

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<400> 53

atgaacacct ctggggtcag ctga

24

<210> 54

<211> 25

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: Primer

<400> 54

gtcctctgca gcattgttcc tctta

25

<210> 55

<211> 26

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: Primer

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26

<210> 56

<211> 24

<212> DNA

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ggatcggagt cactcccttc gctg

24

<210> 57

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<212> DNA

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aatgacactg tactggaggc cacag

25

<210> 58

<211> 24

<212> DNA

<213> Artificial Sequence

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<223> Description of Artificial Sequence: Primer

<400> 58

ctgccatcta ccacacggat ctgc

24

<210> 59

<211> 24

<212> DNA

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<400> 59

cttgccattc caaagcttcc atgc

24

<210> 60

<211> 24

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: Primer

<400> 60

gtacaagtca ggacagtggg tgcg

24

<210> 61

<211> 24

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: Primer

<400> 61

tggatgatgt cagccagcca ctca

24